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ADVANCED MANUFACTURING

ADVANCED MATERIALS

AEROSPACE

ENERGY

ENVIRONMENT

NUCLEAR TECHNOLOGIES

SUPERCONDUCTIVITY

TELECOMMUNICATIONS

Micromachine Technology Project

Details and Current Status of the 'Micromachine Technology Policy'

94FE0881A Tokyo MITI in Japanese 4 Mar 94 p 1

[Article by Tatsuya Fujiwara, R&D Specialist, Industrial Science and Technology R&D Office, AIST, MITI]

[FBIS Translated Text]

1. Implementation of Micromachine R&D

1) Time Frame: 1991-2000 (10 year period)

Phase 1: 1991-1995

Phase 2: 1996-2000

2) R&D Funding: Total funding of ¥25 billion (projected)

3) Participating Corporations: 27 companies and organizations (including 3 foreign companies and organizations)

2. Expected R&D Areas

1) Power plant maintenance systems for inspecting and repairing narrow pipelines, etc. 2) Medical applications for investigation and therapeutic treatment of the human body. 3) Microfactory systems that fabricate precision machines using miniature equipment.

3. Details of Future R&D

1) Power Plant Maintenance: Implement research on functional elemental device prototypes; determine research goals for Phase 2. 2) Medical Applications: Propose intracorporeal diagnostic and therapeutic systems, select necessary technologies specifically suited to medicine from among the component technologies, and begin basic research on them. Determine goals and details of research to be conducted in Phase 1 and Phase 2. 3) Microfactory Technology: Select actuator and manipulator elements from technologies that will be used in power plants.

4. Issues as Research Progresses

1) Research Agenda and Considerations

- Keep the above systems in mind and conduct research on the component technologies they will require.
- Make effective use of phenomena unique to the micro-level environment.
- Dimensions for functional component devices shall be on the μm level.

2) Research Methods and Evaluation

- With respect to reaching the objectives for functional component technologies, the methods of conducting research will vary widely depending on the levels of the objectives and their limitations.
- How decisions will be made when new principles and techniques are discovered during research.
- Evaluation of research will be based on: 1) The performance values such as power output, efficiency, degree of integration, etc., of each functional component that is required for the equipment under study. 2) Technological progress based on a new standpoint that considers the utilization of the special characteristics of the micro-level environment.

5. Other Considerations

- International cooperation
- Cooperation between government, industry, and academia

6. Fields of Application

Micro-Grinding Machining of Micro-Parts

94FE0881B Tokyo MITI in Japanese 4 Mar 94 pp 1-7

[Article by Keisaku Okano, Mechanical Engineering Laboratory, AIST, MITI]

[FBIS Translated Text]

1. Introduction

In recent years R&D has been conducted on micromachines that perform intricate and complex tasks on a very small scale. These include micromachines for industry that perform inspections and repairs in confined spaces such as inside pipelines and micromachines for medicine that enable sophisticated therapies.[1,2] The advent of micromachines will bring about a revolution in the way maintenance is performed on equipment used in industrial technology, in manufacturing methods, and in the methods used in medical examinations and therapy. Much is expected from the ripple effects of micromachine technology.

The development of micromachines that are much smaller, have greater precision, and perform more sophisticated functions than mechanical systems of the past will require the technology to fabricate very small micro-mechanical parts. In this article I would like to discuss the potential of micro-grinding, which is an application of grinding technology, as a method of fabricating micro-parts.

2. Micromachine Parts and Fabrication Methods

2.1 Types of Micromachines

The fundamental difference between micromachines and previous mechanical systems lies in their size, of course, but that concept still has not been clearly defined. Generally, mechanical systems have been classified by the dimensions of their component parts into meter, centimeter, sub-millimeter (or millimeter), micrometer, or nanometer systems as shown in Table 1, and the sub-millimeter or smaller systems are considered micromachines.[3,4]

Table 1. Classification of Micromachines (from Sato, Fujita, et al.)

	Sub-Millimeter Systems (Miniature Machines, Millimeter Systems)	Micrometer Systems	Nanometer Systems
Typical dimensions	0.1-1mm	1-100 μm	less than 1 μm
Materials	Bulk materials (metals, polymers)	Silicon, other thin film materials	Polymers (proteins)
Fabrication method	Precision machining	Semiconductor processes	Undetermined
Structure	Three-dimensional structures	Two-dimensional structures	Molecular structures
Assembly	Difficult, manipulators required	Relatively easy, packaging possible during process	Easy, self-assembly
Actuators	Piezoelectric, electromagnetic, shape-memory alloys	Electrostatic, piezoelectric, thermal expansion	Simulated biological systems (chemical)
Extraction of work	Relatively easy	Difficult, work contained in system	Difficult, work contained in system
Fields of application	Walking and mobile machines; tools for microsurgery; artificial organs; filing devices	Biological and medical (manipulation of individual cells, drug delivery); scientific (scanning tunneling microscope, tools for R&D); industrial (filing devices, micro-flow control)	Unknown

Nanosystems have parts with dimensions of less than 1 μm, and although their fields of application have not yet been clearly defined, they will likely be used as components in quantum technology.

Micromachines have parts with dimensions of 1 μm to about 100 μm. They are expected to find wide-ranging applications in many fields. In the field of medicine, these include micromachines that will inspect the insides of blood vessels and microcapsules that will deliver drugs to afflicted areas. They will also find uses as heads for tunneling microscopes and as optical and magnetic heads.

Micromachines that inspect and repair the insides of pipelines, micromachine hand systems for performing microsurgery and the like will require capabilities such as mobility, transfer of power, and extraction of power. The micro-parts that make up these machines must have the strength and rigidity to withstand these operations. Therefore, it is believed that the sizes of the parts must range from 0.1mm to 1mm, and the machines will belong to the sub-millimeter systems. In addition to machines to make inspections and repairs in factories and the mechanical hands for microsurgery, uses for these machines are likely to include active catheters, active endoscopes, artificial organs, compact and precise analytical devices, integrated circuit chip manipulating devices and so on.

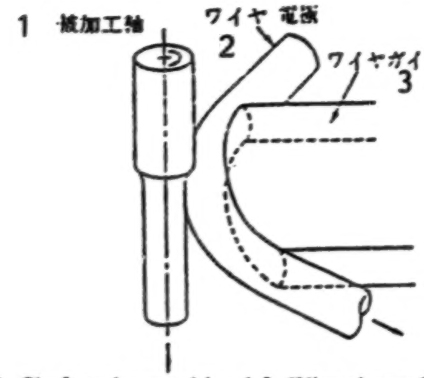
2.2 Micromachine Parts and Their Fabrication Methods

When we organize the various types of fabricating methods in use today by their fabrication dimensions and units of fabrication, the result is something like Table 2 [not reproduced].[5] If we look at the relationship between micro-machine parts and fabrication methods, we find that there is no single fabrication method which can be used to make all micro-parts and that the fabrication methods that are used for parts of different dimensions vary considerably. We also find there are suitable fabrication methods for parts of each dimension.

The method called micromachining is widely known as a machining method for micrometer systems. This method applies integrated circuit manufacturing techniques such as thin film forming, photolithography, etching, FIB (focused ion beam), etc., and features outstanding micro-fabrication capability. It is clear from Table 2 that this method is suitable for machining parts for micrometer systems. At present, however, the drawback is that the structures formed in this manner are two-dimensional, and three-dimensional structural parts are difficult to obtain. R&D is underway on techniques such as the LIGA (Lithographie, Galvaformung, Abformung) process and anisotropic etching for creating three-dimensional structures.[6]

Current machining methods still show promise as machining methods suitable for sub-millimeter systems. Among these, grinding enables high-precision machining. It is believed that grinding may become a useful method for machining sub-millimeter system parts if the capabilities of new micro-grinding techniques are pursued to the greatest extent possible. Micro-electric discharge machining, which is an extension of conventional electric discharge machining, has already come to occupy an important role as a micromachining process (Figure 1).[7]

Fig. 1. Micro Electric Discharge Machining (Wire Electrical Discharge Grinding Process)



Key: 1. Shaft to be machined 2. Wire electrode 3. Wire guide

3. Micro-Grinding as a Micromachining Method

3.1 Features of Grinding

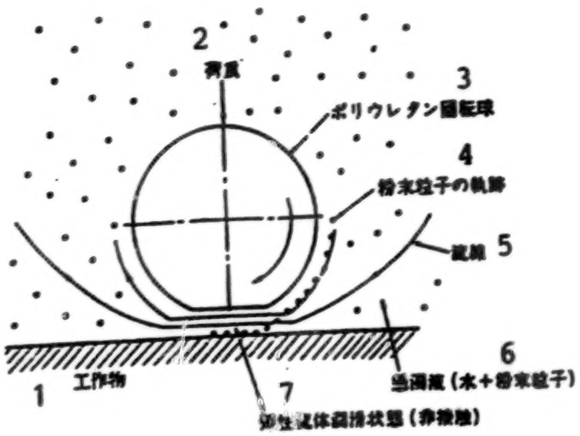
Micro-parts must have good surface smoothness and shape accuracy. When we seek shape accuracy in machine parts, in many cases what is important is the relative accuracy as determined by shape accuracy/part dimensions or smoothness/part dimensions. For example, the relative accuracy of a rod 10mm in diameter that is finished to a true roundness of 1 µm is 10 times less than that of a rod 1 meter in diameter that is finished to a true roundness of 10 µm. This clearly shows that highly precise machining is necessary for micro-parts because of their very small dimensions.

Even though it is a conventional machining method, grinding is known for such outstanding features as the fact that accurate dimensions and good surface smoothness can be obtained, that it can be used to machine very hard materials such as cemented carbide and heat-resistant alloys, that it can be used to machine parts with three-dimensional shapes, and that there are no restrictions on the material to be worked.

In material removal operations, there is a close tie between machining precision and the size of the swarf removed. The removal of ultrafine swarf is necessary for ultra-precision machining. Because grinding is a process that is carried out by a large number of very fine abrasive grains, the swarf it produces is very fine with dimensions of one micron or smaller. Therefore, although it seems clear that grinding can be used for micromachining, what is still unclear is how far micromachining can get with grinding. Moreover, although the amount of material removed by a single abrasive grain is very small, a practical level of machining efficiency can be obtained with grinding because many abrasive grains are acting simultaneously.

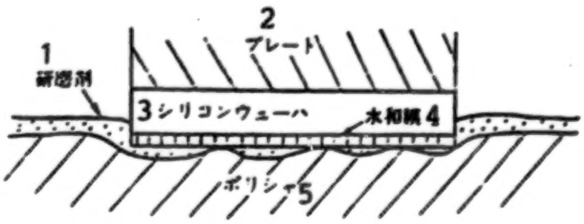
Even machining on the nanometer order is possible with machining methods that utilize abrasive grains, such as EEM (Elastic Emission Machining[8]) (Fig. 2) and mechano-chemical polishing[9] (Fig. 3). Right now it is difficult to utilize these methods for machining complex shapes, but in the future it will probably be necessary to apply the machining principles involved in these kinds of ultra-precise machining processes.

Fig. 2. EEM (Elastic Emission Machining)



Key: 1. Workpiece 2. Load 3. Rotating polyurethane ball 4. Track of powder grains 5. Flow line 6. Liquid suspension (water + powder grains) 7. Elastic fluidized lubrication (non-contact)

Fig. 3. Model of Mechanochemical Polishing of Silicon Wafer



Key: 1. Abrasive 2. Plate 3. Silicon wafer 4. Water dispersion film 5. Polisher

3.2 Problems With Micro-Grinding

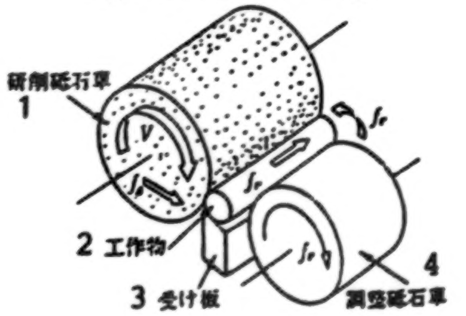
Grinding is a mechanical process, and it is a process in which the machined material is removed in the form of swarf, so the generation of grinding forces associated with machining is unavoidable. In the case of micro-grinding, the parts to be machined are very small, so problems arise that are unique to micromachining such as the deformation (and in some cases even rupture) of the workpiece by the action of these grinding forces. High-precision machining is impossible when deformation of the workpiece occurs, and technology for preventing this kind of workpiece deformation is vital for the realization of high-precision micromachining.

Possible methods of preventing workpiece deformation include using devices to prevent deformation, reducing the grinding forces, and using workpieces made of appropriate materials.

3.2.1 Direct Prevention of Workpiece Deformation

Centerless grinding is one grinding method that can prevent deformation of the workpiece (Fig. 4). Centerless grinding is a method used for grinding cylindrical surfaces such as piston pins and roller bearings. The workpiece is held in place by a support plate and regulating drive wheel on its circumference rather than by a center hole, and the surface is ground by driving the workpiece itself. Machining of miniature cylinders with high aspect ratios is possible, but the shape of the workpiece is limited to simple cylinders, so it will be difficult to adapt this method for machining complex shapes.

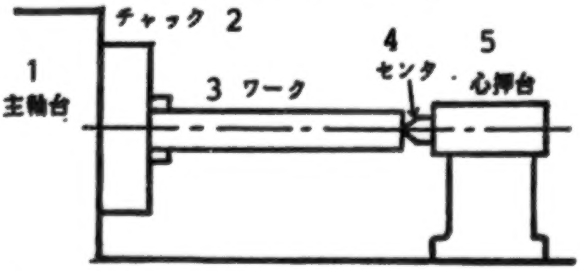
Fig. 4. Centerless Grinding



Key: 1. Grinding wheel 2. Workpiece 3. Support plate 4. Regulating wheel

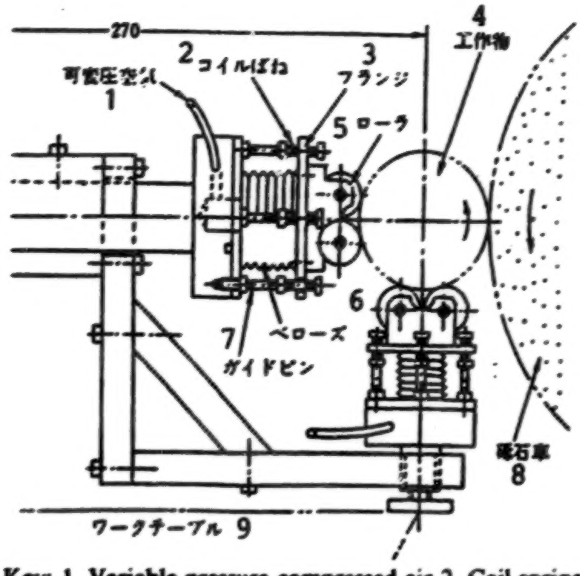
Devices that directly prevent deformation of the workpiece include those in which machining is performed by supporting the piece by a center hole (Fig. 5) or using a work rest (Fig. 6). However, when we think about grinding a cylindrical shape 1mm long and 50 µm in diameter, both supporting it by a center hole and using a work rest will be impossible. Devices that directly prevent workpiece deformation are not suitable for this kind of micro-grinding.

Fig. 5. Center Hole Grinding



Key: 1. Main pillow block 2. Chuck 3. Workpiece 4. Center pin 5. Tailstock

Fig. 6. Grinding Resistance Compensating Compressed Air Active Rest (from O. Horiuchi, T. Nishimoto: Proc. of 26th MTDR (1986) 383)



Key: 1. Variable pressure compressed air 2. Coil spring 3. Flange 4. Workpiece 5. Roller 6. Bellows 7. Guide pin 8. Grinding wheel 9. Work table

3.2.2 Preventing Workpiece Deformation by Reducing Grinding Pressure

Workpiece deformation is caused by the action of grinding forces, and it can be curtailed by reducing the grinding forces. Methods of reducing the grinding forces include:

(1) Micro-swarf removal,

(2) Using a grindstone with good cutting properties,

(3) Improving the grinding properties of the workpiece, and

(4) Using material for the workpiece that does not deform easily.

(1) Micro-Swarf Grinding by Micro-Cutting Mechanism

It is possible to make the swarf very fine by: (1) Micro-cutting, (2) Speeding up the grindstone, (3) Reducing the feed rate, and (4) Increasing the number of effective abrasive grains. To realize this, it is necessary to have a micro-feed control mechanism and a high-precision, high-speed grinding shaft that will make micro-cutting possible. In addition, sophisticated cutting technology, such as a method to adjust the height of the cutting tool (grindstone) is needed. Cutting on the nanometer level will only be possible by using the sharp, fine edges of ultrafine abrasive grains (CBN, diamond) with a high-speed cutting tool mechanism and a micro-feed mechanism that sets the height of the blade. With this technology it will be possible to minimize the grinding forces.

(2) Achieving a Good Cutting Edge

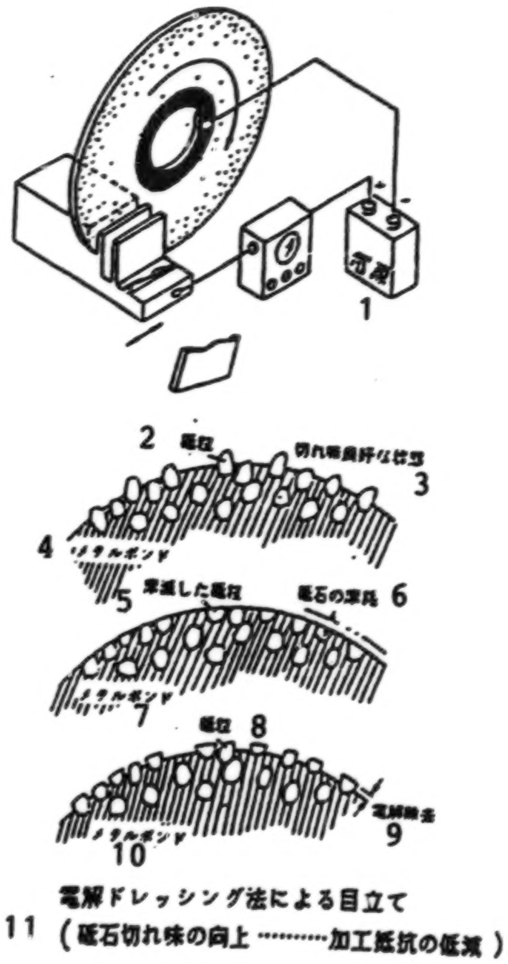
To realize the low grinding forces that are essential to micro-grinding, it is only natural that the grinding parameters be set to generate micro-swarf, but it is also necessary to use a grindstone with sharp cutting properties. Fine-grained grindstones are widely used to realize micro-swarf in micro-grinding. To have good cutting properties on the grindstone, it is necessary that the abrasive grains protrude, but it is not easy to realize a situation in which fine abrasive grains protrude. It appears, however, that electrolytic dressing is an effective method for achieving this condition (Fig. 7).[10]

Electrolytic dressing uses an electrolytic fluid along with the cutting fluid. An electric current flows between an electrode and the metal-bonded grindstone. The bonding material is removed by electrolysis so that the abrasive grains protrude, and this improves the cutting properties of the grindstone. It is possible to remove small amounts of bonding material, which facilitates the dressing of fine-grained grindstones, by controlling the quantity of electric current. Dressing can be performed during the grinding process.

(3) Improving the Grinding Properties of the Workpiece

To reach a higher level of sophistication in micromachining it will be necessary to study combining micro-grinding with machining methods that do not use force to remove material from the workpiece such as electrolytic machining. Here I would like to touch on electrolytic grinding, which combines electrolysis and grinding. Figure 8 shows the machining mechanism for electrolytic grinding. The aim is to use grinding to compensate for the loss of shape accuracy in the workpiece caused by removal of material by electrolytic action or to use electrolytic action to form a film that has good grinding properties and then grind that film away. From a theoretical standpoint, there are no machining forces involved in removing the material by electrolytic action, so we can expect an improvement in micromachining results. The structure of the electrolytic grinding device is almost the same as that shown in Fig. 7. In electrolytic dressing the grindstone is connected to the positive terminal, but in electrolytic grinding it is the workpiece that is connected to the positive terminal. However, materials suitable for electrolytic grinding are limited to those that conduct electricity.

Fig. 7. Electrolytic Dressing



Key: 1. Power source 2. Abrasive grain 3. Good cutting properties 4. Metal bond 5. Worn down abrasive grains 6. Worn grindstone 7. Metal bond 8. Abrasive grains 9. Electrolytic removal 10. Metal bond 11. Grains stand out after electrolytic dressing (Improves grindstone cutting properties, reduces processing resistance)

3.2.3 Selection of Non-Deforming Workpiece Materials

Let us consider a simple case of workpiece deformation in micro-grinding a cylinder. A uniform load from the grindstone *w* acts on the radius *r* and the length *l* of the workpiece, and this causes deformation of the workpiece. At this time, the deflection on the tip of the workpiece b_1 can be determined from the following equation by using the material strength formula for deformation of a beam that is fixed at one end.

(1) $b_1 = wl^4/(2\pi E r^4)$

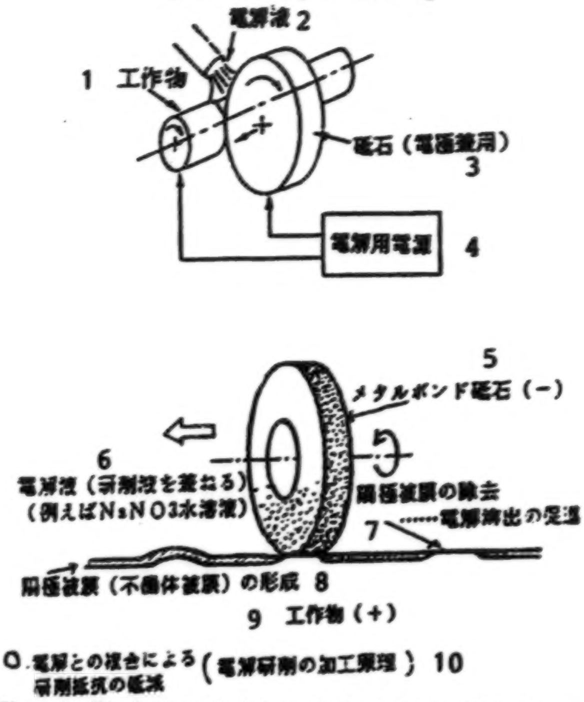
In this formula, *E* is Young's modulus, *r* is the radius of the workpiece, *l* is the length of the workpiece, and *w* is the uniform load.

The amount of deflection is proportional to the magnitude of the load and the 4th power of the length of the cylinder. It is inversely proportional to the 4th power of the radius of the workpiece. It is clear that machining becomes more difficult as the radius becomes smaller or the aspect ratio becomes larger. Because the amount of deflection increases as Young's modulus *E* decreases, it is desirable for the workpiece material to have a large Young's modulus so it can be machined with small grinding forces.

4. Micro-Grinding Tests for Micromachining

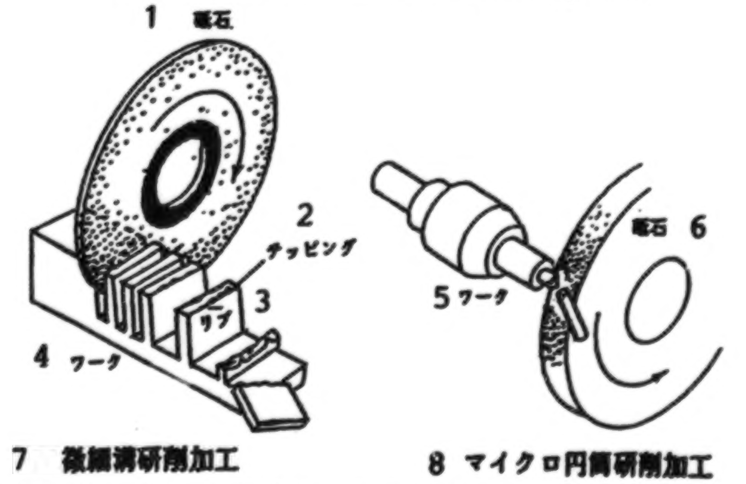
As shown in Figure 9, we have performed micro-grinding tests to form micro-slots and micro-cylinders. We investigated the minimum dimensions that can be obtained with micro-grinding, machining precision, and micro-grinding properties in order to explore the potential of micro-grinding as a micromachining method (see reference documents I, I and III).

Fig. 8. Electrolytic Grinding



Key: 1. Workpiece 2. Electrolytic fluid 3. Grindstone (connected to electrode) 4. Electrolytic power source 5. Metal-bonded grindstone (-) 6. Electrolytic solution (together with cutting fluid) (For example, aqueous solution of $NaNO_3$) 7. Removal of anodic film, progress of electrolytic elution 8. Formation of anodic film (non-conductive film) 9. Workpiece (+) 10. Reduction of grinding resistance by combining grinding with electrolysis (Machining Principle of Electrolytic Grinding)

Fig. 9. Grinding of Micro-Slots and Micro-Cylinders



Key: 1. Grindstone 2. Chipping 3. Rib 4. Workpiece 5. Workpiece 6. Grindstone 7. Micro-slot grinding process 8. Micro-cylinder grinding process

5. Conclusion

With micro-slot grinding we formed ribs 8 μm thick and 200 μm high, and with micro-cylinder grinding we formed cylinders 50 μm in diameter and 3mm long.[5,11,12] Through these tests we were able to understand the advantages of micro-grinding and identify problems that need to be addressed. Moreover, we learned that micro-grinding is a useful process. Because it is believed that the technology for fabrication of sophisticated tools (micro-grindstones) is especially important, we plan to investigate ways to raise the level of micro-grinding techniques even higher with a focus on micro-tool technology.

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Three-Dimensional Micromachining With Micro-Electron Gun

94FE0881C Tokyo MITI in Japanese 4 Mar 94 pp 1-5

[Article by Junshi Itoh, Electrotechnical Lab, AIST, MITI]

[FBIS Translated Text]

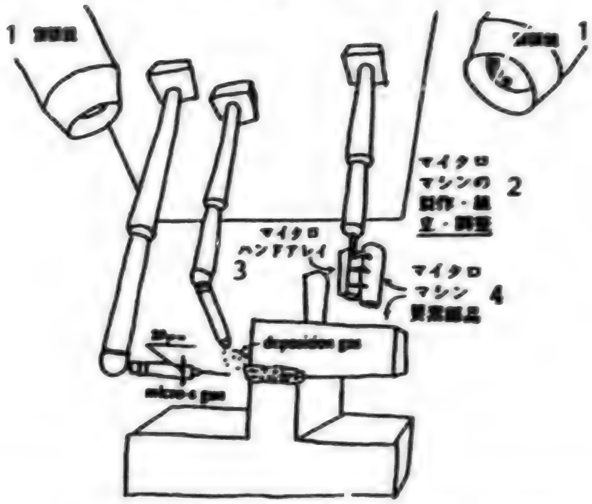
1. Introduction

Research on sub-millimeter scale micromachines has become quite active in recent years. The main uses of micromachines will be inside human blood vessels, power plant pipelines and so on. It is expected that self-propelled robots will be able to move at will through environments that are difficult to access with today's technology. Large-scale integrated circuits (LSI) have dramatically enhanced the capability of semiconductor devices through integration and miniaturization of their dimensions. In the same way, we can expect the integration and miniaturization of machine parts to increase their effectiveness tremendously, both in terms of their applications and their capabilities. In that sense we can say that research efforts directed toward the realization of micromachines is headed in the right direction. However, many important technologies must be developed for us to realize true micromachines that can be used in the applications noted above. Naturally, important elements of development include technology concerning mobility mechanics and mechanisms, surface friction, and remote control. In any event, however, the problem is how can we machine miniature parts several tens of micrometers in size in three-dimensions to the desired shapes and then assemble them? Right now LSI fabricating techniques such as photolithography are used, but these techniques alone are insufficient.

We propose a three-dimensional machining technique utilizing a micro-electron gun that generates a powerful, focused electron beam smaller than the parts to be machined as a method to solve this problem, and we have conducted research toward that goal. Figure 1 shows the concept behind this technique. The ultimate goal of this technique is to manipulate electron guns several micrometers in size from any desired direction to cut out the parts, bond them, etc., simultaneously as beam progresses. In moving toward this objective, we are

currently involved in the development of a high-performance micro-electron gun, and we have succeeded in building and operating a prototype of the first micro-electron gun in the world.

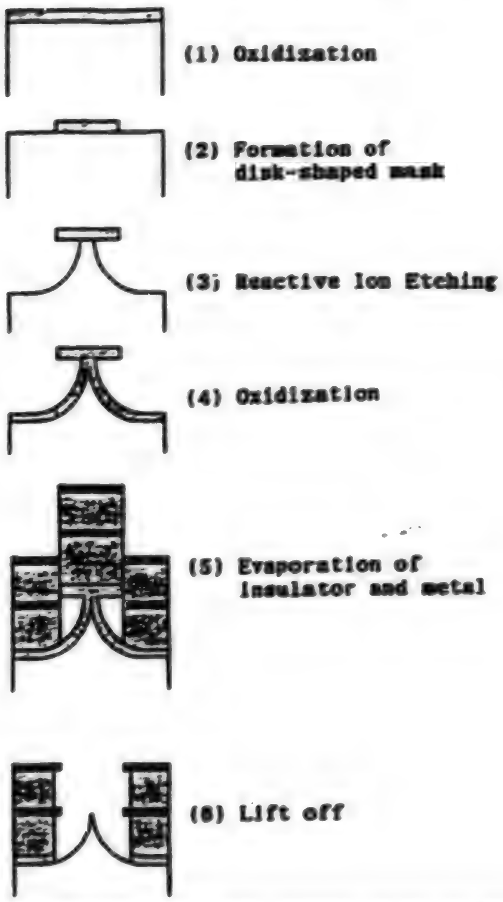
Fig. 1. Conceptual Drawing of Three-Dimensional Micromachining Technique Utilizing Micro-Electron Gun



Key: 1. Electron microscope 2. Fabrication, assembly, and adjustment of micromachines 3. Micro-hand array 4. Micromachine component parts

In this article we will discuss the structure and manufacturing process of the micro-electron gun, simulation results of its expected properties, and an initial evaluation on the prototype electron gun.

Fig. 2. Fabrication Process



2. Structure and Manufacturing Process of the Micro-Electron Gun

The structure of the micro-electron gun discussed herein is a triode: a cone-shaped field emitter formed from a silicon base and a two-stage control electrode surrounding it interspersed by layers of insulation.[1,2] Figure 2 illustrates the manufacturing process. First, a disk-shaped thermal oxide film about 2 µm in diameter is formed on the silicon base (steps 1 and 2). The silicon is machined into the shape shown in step 3 by reactive ion etching (RIE) with the use of a mask. Then thermal oxidation is repeated and vacuum deposition is used twice to create alternating layers of insulation and electrodes (steps 4 and 5). Finally the gun is lifted off in buffered hydrofluoric acid to complete the manufacturing process.

The insulation layers are about 1 µm thick, and they are formed by SiO deposition in an ozone atmosphere. Layers of niobium (Nb) about 0.3 µm thick deposited by an electron beam are used for the electrodes. The special features of this fabrication process are that the field emitter is formed by a combination of dry etching and thermal oxidation[3], and the two-stage electrode is formed in a self-matching manner by using the mask that is used for the emitter without change. As a result, throughout the whole process high-precision alignment is unnecessary.

The current properties of the field emitter are highly dependent on the sharpness of the emitter tip and the distance between it and the first-stage electrode (the gate electrode). Emitters manufactured by this method have a radius of curvature at the tip of 30 nm or less, which is sufficiently sharp.

Figure 3 shows SEM photographs of the manufacturing process after completion of steps 3 and 5. Figure 4 shows an SEM photograph of the completed elements. The first-stage electrode has an aperture diameter of 2 µm and the second-stage electrode 3 µm. The aperture diameter of the second-stage electrode is larger because the mask diameter is effectively enlarged during the deposition process (step 5 in Fig. 2) since deposition on the surface of the mask also occurs.

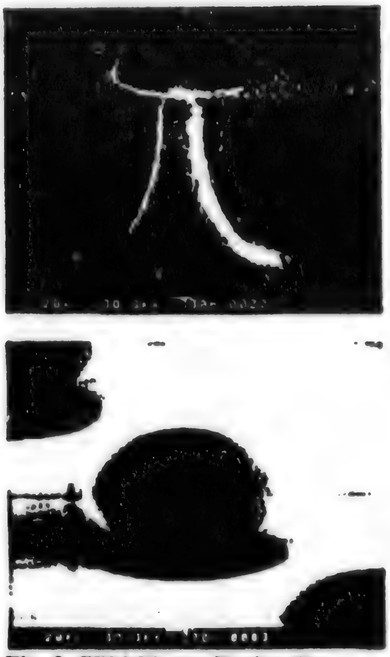


Fig. 3. SEM Photos During Process

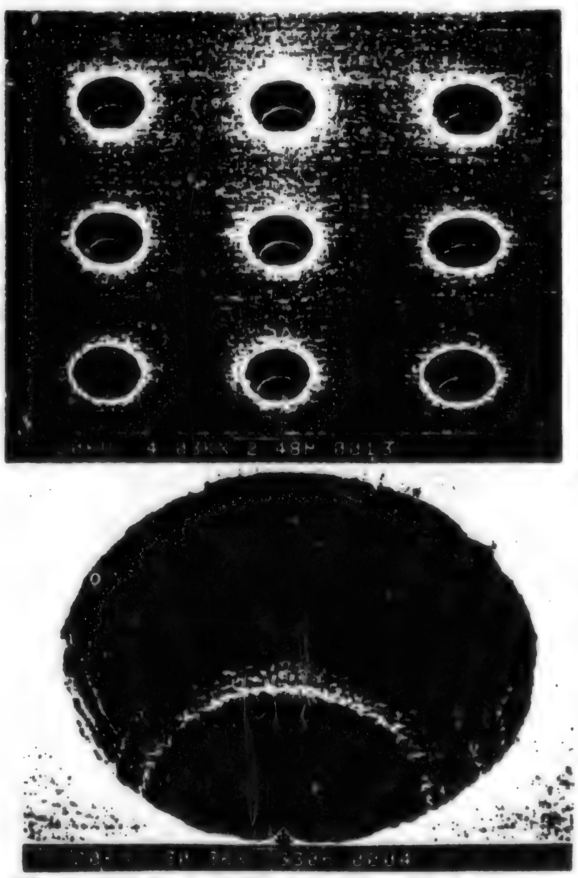


Fig. 4. SEM Photo of Finished Micro-Electrode Gun

3. Properties

In this electron gun we use the gate electrode as an electrode to attract emissions from the field emitter and the second-stage electrode as an electrostatic lens to control the path of the electrons emitted from the tip of the emitter. Therefore, the voltage applied to the gate electrode is about 100V, and the voltage applied to the lens is adjusted to a suitable voltage based on the gate electrode voltage.

Calculations indicate that with this μm-order micro-electron gun optical system we can achieve an intensity 1,000 times greater than with previous millimeter-order electron guns.[4] Moreover, by setting the lens to appropriate voltages, the paths of the electrons emitted from the emitter can be made to scatter or converge as shown in Figure 5. By making use of this phenomenon, it is possible to generate a very high-intensity electron beam with a diameter of about 10 nm.

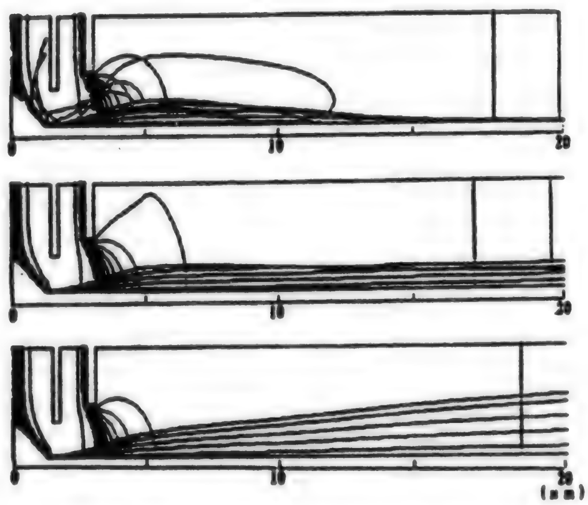


Fig. 5. Simulation of Convergence Properties

Figure 6 shows the result when we actually operated the prototype electron gun.[5] Simply put, in this test we placed a fluorescent screen about 10mm away from the electron gun, illuminated it with the electron beam generated by the electron gun, and observed the fluorescence pattern. At that time we set the gate electrode to 80V and varied the range of the converging lens from 5V

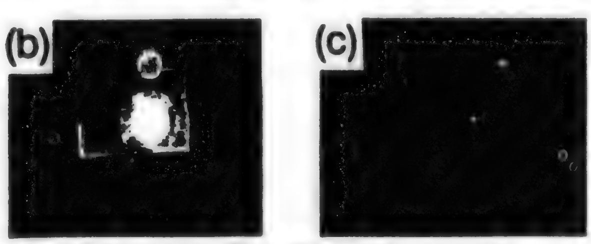


Fig. 6. Convergence Tests Using Fluorescent Screen

to 80V. In the figure, (b) and (c) are photographs of the fluorescence pattern at 80V and 6V, respectively. It is clear from the figure that as the lens voltage is reduced the diameter of the beam becomes narrower.

Qualitatively our results show good correlation with the results of the simulations noted previously. In the future we plan to use this electron gun for high aspect ratio machining of photoresist, etc.

Finally, we sincerely thank Mr. Seigo Kanemaru and Kazutoshi Morikawa for their valuable support in building the electron gun prototype.

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New Development and Usefulness of CBN Tools

95FE0148A Tokyo KIKAI SHINKO in Japanese
Nov 94 pp 60-65

[Article by Kazuhiko Yokokawa, instructor, Precision Engineering Faculty, Department of Science and Engineering, Meiji University]

[FBIS Translated Text]

New Development and Advantages of CBN Wheel and CBN Grinder

The CBN wheel for grinding has unique features that the ordinary grinder does not have. This is demonstrated in the fatigue strength and abrasion resistance of the object of the grinding. Here, the use of the CBN wheel will be discussed with emphasis on improving productivity.

Advantage of Prismatic Diamond Dresser

The dressing work done by single-stone diamonds of octahedral (pyramid with pointed end) and prismatic (pillar-like form with 0.2mm x 0.3mm edge) shapes will be compared. Figure 1 shows the dressing performance of existing types of single-stone octahedral diamond dressers and single-stone prismatic diamond dressers. When a single-stone octahedral dresser wears down, the area of contact by dresser and wheel increases, dressing resistance increases and wheel fairing precision decreases. When this happens, a sharp cutting edge cannot be formed.

With a single-stone prismatic dresser, the point of contact of the wheel and dresser is small and remains the same even when the dresser wears down. Therefore, dressing resistance also remains the same, a sharp cutting edge can be formed consistently and grinding surface roughness also remains the same. Moreover, the diamond's crystal orientation can be set to the dressing's abrasion-resistant orientation during dressing; and this makes it difficult to wear down. Therefore, in the future, inexpensive, high-performance prismatic diamonds can be used instead of natural diamonds.

Advantage of Dressing by Combination Work Head and Rotary Dresser

As shown in Figure 2, in CBN wheel grinding, the rotary diamond dresser is operated up and through against the wheel so that the wheel is formed with the correct rotational precision. Then, down-dressing is carried out, using a rotary diamond dresser with a circumferential speed of about 0.9 times the circumferential speed of the wheel, to form it with an abrasive grain cutting edge and a perfect cutting edge with about 5 micron roughness, and low grinding resistance and high compression residual stress cannot be achieved without grinding.

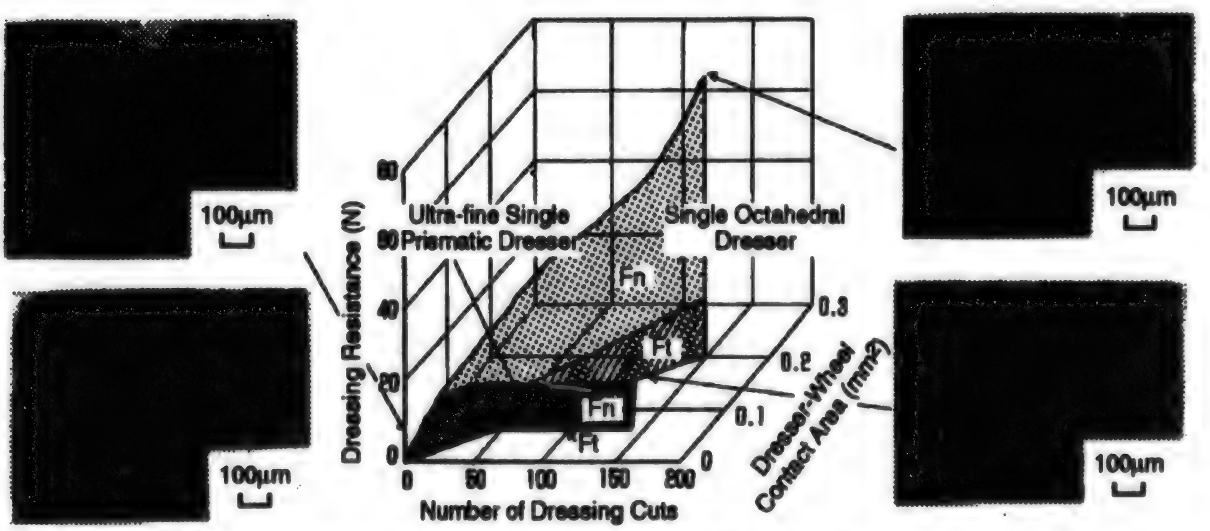


Figure 1: Dressing Performance of Single Octahedral Diamond Dresser and Single Prismatic Diamond Dresser

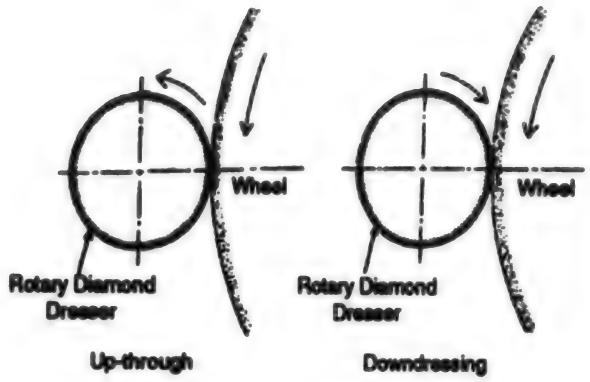


Figure 2: Up-through and Downdressing

1. Prismatic Diamond Rotary Dresser With Positive/Reverse Rotating Oil Pressure Bearings

High-precision, high-efficiency grinding cannot be achieved without using oil pressure bearings, i.e., wedge and oil-film type bearings, as grindstones. Figure 3 is a longitudinal cross-section of the structure in which a prismatic diamond rotary dresser has been attached to the work head. This made positive and reverse rotation possible by applying the principle of these bearings. Figure 4 is a perpendicular cross section which shows the state of the wedge and oil film as well as pressure distribution during positive and reverse rotation.

The main spindle rotates in both positive and reverse direction with stability because it is under strong pressure pushing from three directions toward the core direction. Figure 5 shows the relationship between tangential grinding resistance and grinding surface roughness when ground at 1200mm^2/min with a wheel that was downdressed with a 0.9 speed ratio.

In the past, because dressing methods were bad, there was no compression residual stress even when ground with a CBN wheel, or grinding resistance was higher than with regular grindstones; and there was a tendency for grinding resistance to be high at the outset and then decrease with increase of the grinding cross section per unit circumferential length of the wheel. Some people say that the CBN wheel cannot be used, but this has been completely changed so that it can grind from start to finish with uniform grinding resistance that is lower than that of regular grindstones.

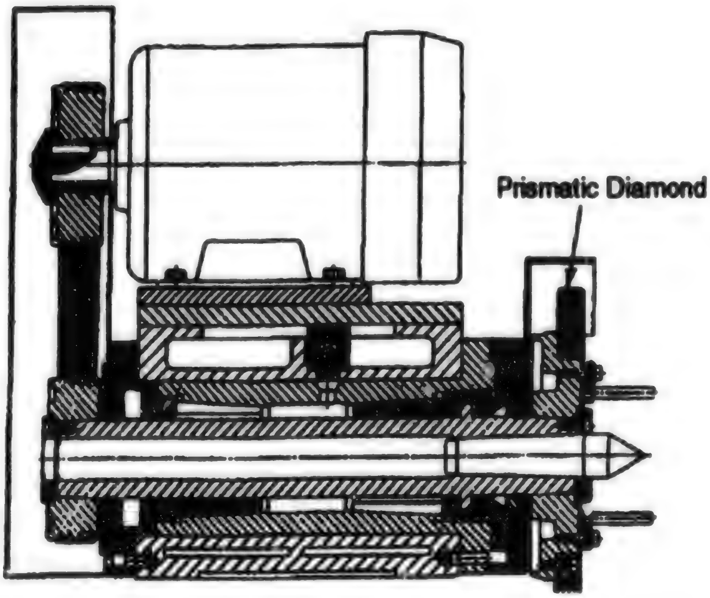


Figure 3: Longitudinal Cross-Section of Prismatic Diamond Dresser with Positive/Reverse Rotating Oil Pressure Bearings

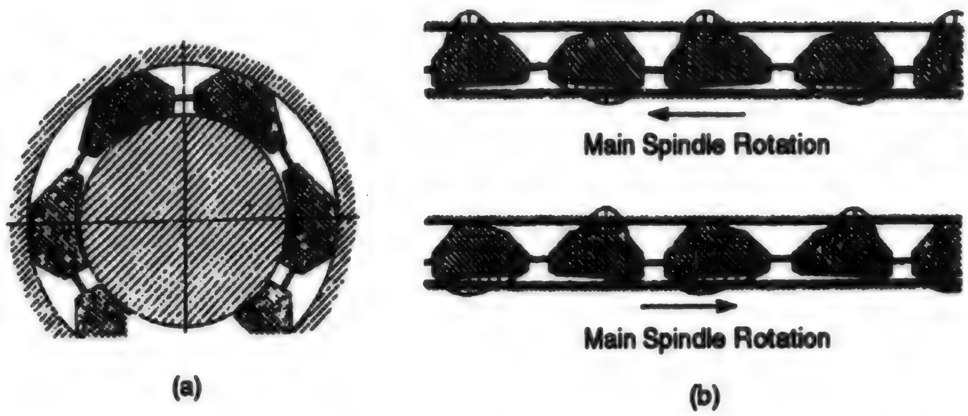
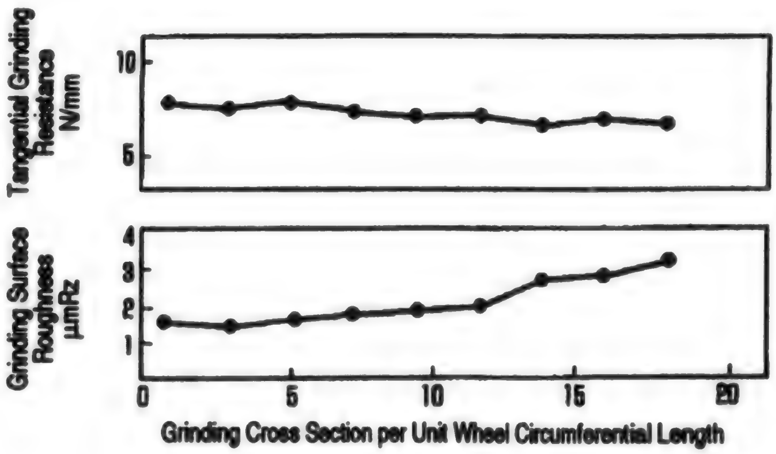


Figure 4: Main Spindle Rotation Direction and Pressure Generated by Wedges



Grinding Specifications:

Machinery: MUG27-50 Cylindrical Universal Grinder; made in 1967 by Mitsui Seiki
Wheel: CBN (Type 1) 80/110 W_1 200VN4
Workpiece: MGF-3 (1:20), Supplied by Wound Nozzle
Wheel Circumferential Speed: 3600 m/min
Workpiece Circumferential Speed: 45 m/min
Grinding Cross Section per Minute: 1200 mm^2/min
Dressing Specifications:
Dresser: Prismatic Diamond Rotary Dresser with Positive/Reverse Rotating Oil Pressure Bearings (ø 225mm)
Lead: 0.1 mm/rev
Downdressing Ratio: 0.9
Cut Volume: ø5.0μ x 4

Figure 5: Grinding Performance at Downdressing Speed Ratio 0.9

2. Combination Rotating Dresser and Work Head for R and Unique Shape Dressing

Attaching the rotary dresser shown in Figure 6 to the main spindle makes it possible to dress the front and side surfaces of the wheel with the combination dresser and work head whose structure was mentioned earlier. However, precision dressing of the R section is not possible with XZ two-spindle control.

Consequently, the structure of the work head for dressing is designed so that the work head is installed on an NC rotating table and the rotary dresser comes over the rotating central spindle, as shown in Figure 7 and Figure 8. Also, the X, Z and B spindles are controlled so that the diamond is always in a normal line orientation with the contour of the wheel that is to be dressed.

In this way, dressing of the R configuration as well as the wheel used for ball thread grooves, which is shown in Figure 9, and the wheel used for grinding standard shaped gears, which is shown in Figure 10, can be done in combined use with the work head.

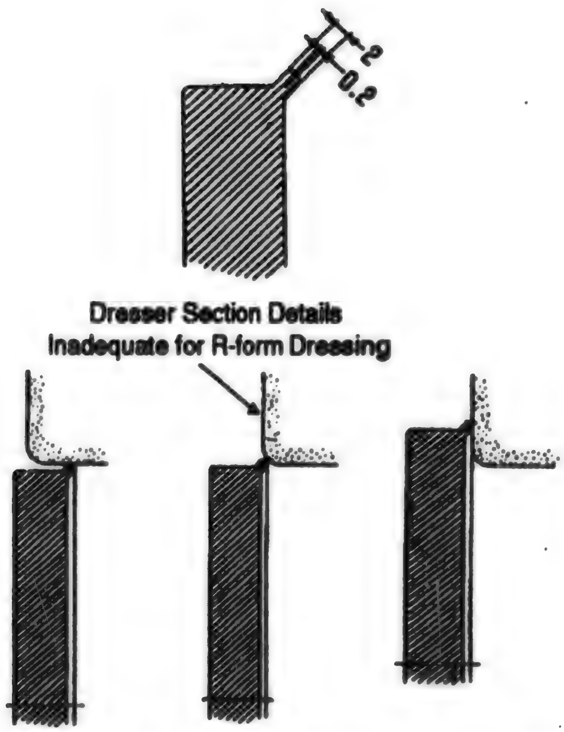


Figure 6: Throughing and Dressing of Wheel Front and Side Surfaces

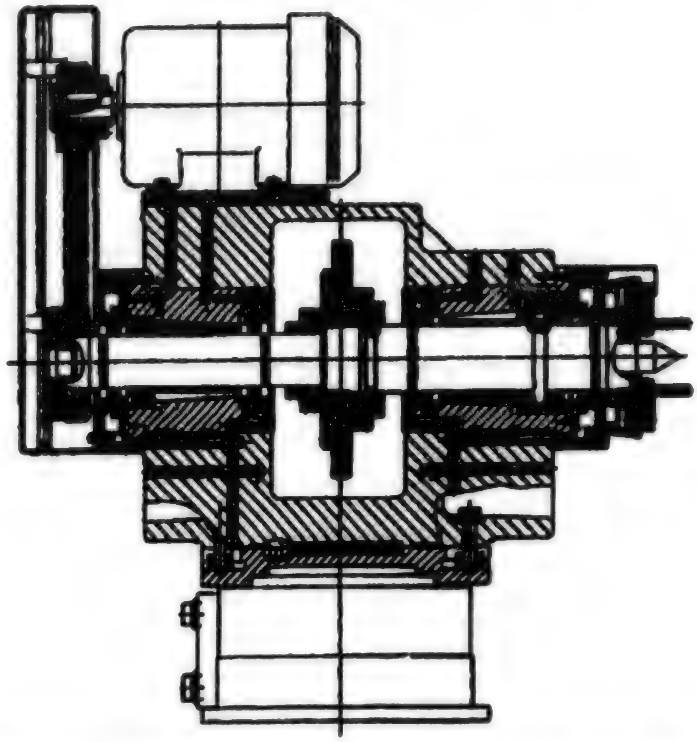


Figure 7: Longitudinal Cross Section of Positive/Reverse Rotating Prismatic Diamond Rotary Dresser for Grinding Ball Thread Grooves and Standard Shape Gears

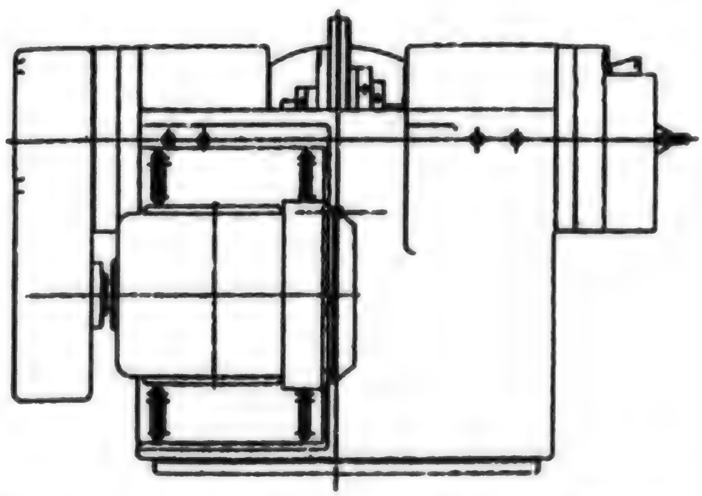


Figure 8: Drawing of a Positive/Reverse Rotating Prismatic Diamond Rotary Dresser for Grinding Ball Thread Grooves and Standard Shape Gears

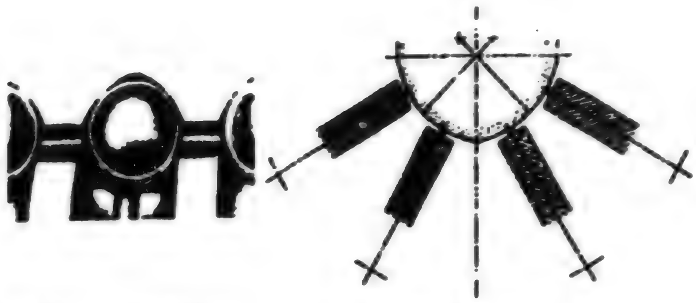


Figure 9: CBN Wheel CNC Dressing for Ball Thread Groove Grinding

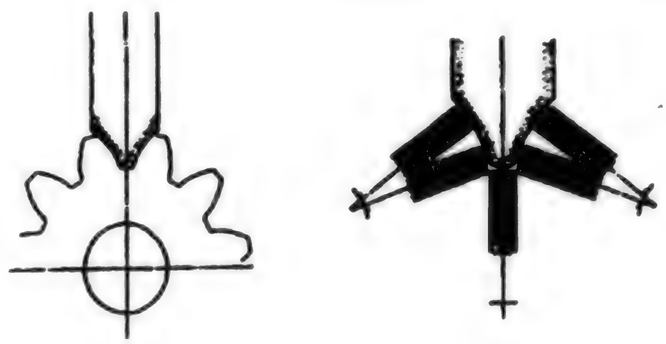


Figure 10: CBN Wheel CNC Dressing for Standard Shape Gear Grinding

Design of Grinder for Contour Grinding and Its Advantages

Angular slide grinders with general types of grindstones have been used to grind pieces in stages. The CBN wheel was developed when production had shifted to the production of many types of pieces in small volume and a lot of time was being spent changing grinders for the stages; and the contouring grinder using the CBN wheelwas developed, which uses the wheel's unique features—no wearing down and a low grinding resistance that is half of regular grindstones—and which combines shoulder, flange and traverse grinding that can be done by the narrow-width wheel.

1. Existing Contouring Grinders

As shown in Figure 11, for existing contouring grinders, the grindstone spindle is attached parallel to table motion. In Process (1), the CBN grinds the edge of the workpiece with the wheel edge, then does the grinding in Processes (2), (3) and (4) in the traverse direction. As shown in Figure 12, wheel wear after grinding 1,300 pieces is quite substantial; on the edges alone, the peripheral section is worn down by 0.4mm and the side surface by 0.35mm. This is because, as stated earlier, the edges of the workpieces are ground by the wheel edges. Additionally, the wheel periphery in the traverse direction is worn down by 0.08mm. Furthermore, the workpiece edges are easily burned because they are in substantial contact with the side surfaces of the wheel during grinding.

Even when there is a gap between the workpiece edge and body, as shown in Figure 11, dressing frequency is high and substantial volume is removed by the dressing, so the CBN wheel is being used to no avail. That being the case, how can the wheel be used effectively to grind a workpiece that is strengthened and in which the edges and body are linked by R?

2. Advantages of New Contouring Grinder and New CBN Wheel

Our consideration now will be extended to the case shown in Figure 13, where the workpiece edges and body

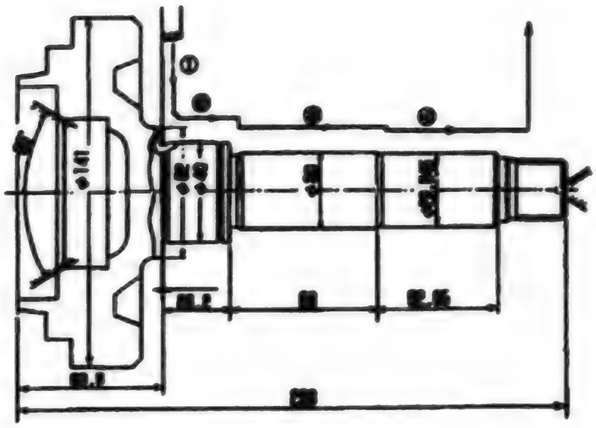


Figure 11: Existing Contour Grinding

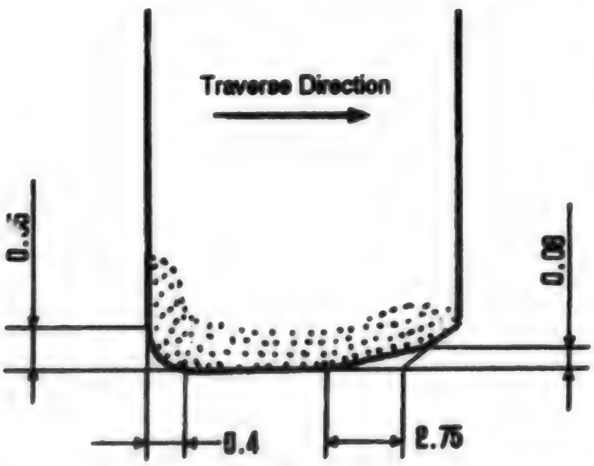


Figure 12: Wearing of CBN Wheel for Contouring

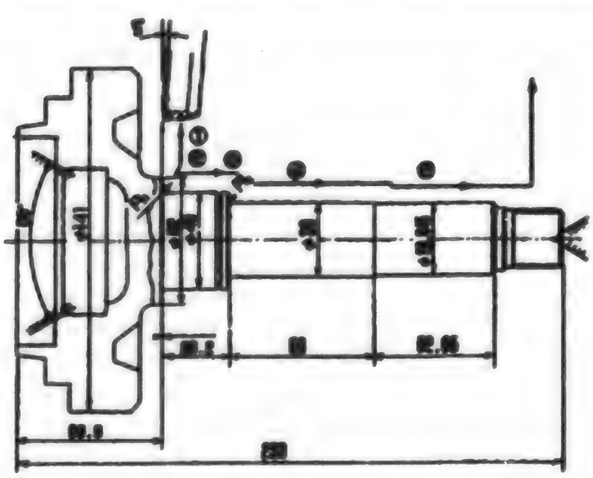


Figure 13: New Type of Contour Grinding

are linked by R. First, instead of grinding with the wheel edge as shown in Figure 11, an angular CBN wheel tilted by 5° is used, as shown in Figure 13. After rapid traverse in Process (1), the edge is ground with an angular side in Process (2). The workpiece edge and wheel are in line contact, not in full contact as shown in Figure 11, so there is little burning. Finally, the grinding in Processes (2), (3) and (4) are done in the traverse direction.

This virtually eliminates the wheel edge wearing that occurs with existing contour grinders. Additionally, if degree of coupling is tight on the left side of the wheel and gradually loosened towards the right side so that there is about two stages of difference between the two sides, the slanted wearing by the CBN wheel traverse shown in Figure 14 can be prevented and there will be uniform, very slight wearing of both left and right sides during grinding. Then there will be no need for dressing, the life of the CBN wheel will be extremely long, and the unique feature of the CBN wheel, its large grinding ratio, can be fully utilized.

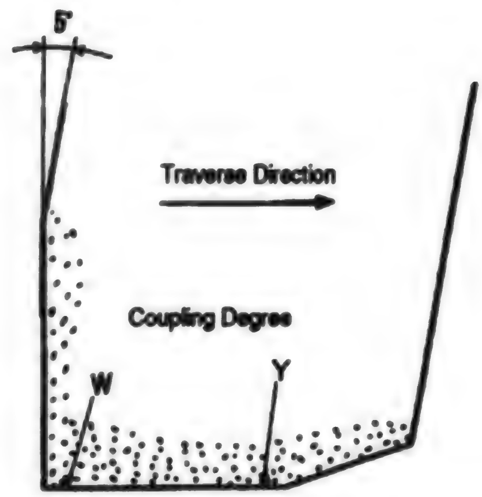


Figure 14: Composition of CBN Wheel for Contouring

Also, coolant supplying by a nozzle wound around the outer circumference of the wheel is effective for a super high-speed grinding apparatus, but an effective method for supplying coolant to the wheel sides and edges is shown in Figure 15. A spiral groove is cut into the side of the wheel, coolant is poured onto the wheel sides and is supplied to the sides and edges by the centrifugal force of the revolution of the wheel. In this way, coolant is supplied to all grinding parts and wearing of the edges and burning of the workpiece edges can be prevented completely.

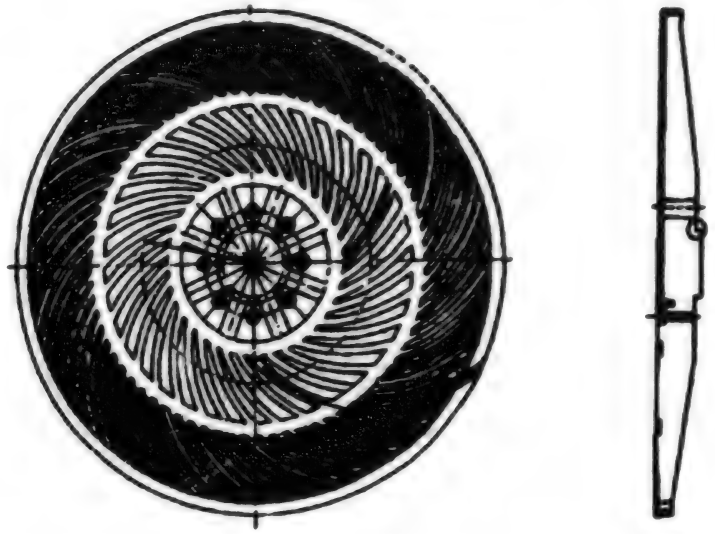


Figure 15: Side Coolant Supply Type Super High-Speed Wheel

Advantage of New Through-Liquid Grinding Wheel

In 1957, a method of supplying coolant to the grinding point known as the through-liquid grinding method was attempted, in which coolant was to be supplied to the grinding point through air holes in a traditional vitrified grinder, but the coolant could not be filtered adequately, so the air holes were stopped up by cuttings and the through-liquid method was inoperable.

Subsequently, the wound nozzle and three-surface wound nozzle methods were developed[1], and they are being used now for complete supplying of coolant to the grinding point. However, today's operators say that it is a bother to set the direction of coolant spray from the nozzle in a normal line vis-a-vis the wheel, so the new through-liquid grinding method for CBN wheels, as shown in Figure 16, was developed.

The coolant is supplied from a notch in part of the flange side to the inner diameter of the CBN wheel, goes through slots opened in the core and is sprayed from the outer circumference by centrifugal force. In other words, the coolant is supplied directly to the grinding point.

It is possible to set up coolant supply only to the CBN wheel external circumference surface, as shown in Figure 17, then cut supply holes in a zigzag pattern. When grinding is done with both edges, the coolant supplying can be set up as shown in Figure 18. Wearing of the wheel edge when grinding end mill grooves can be prevented by slight alteration. The method shown in Figure 19 is for cases where coolant supplying to the edges of an angular wheel is a problem.

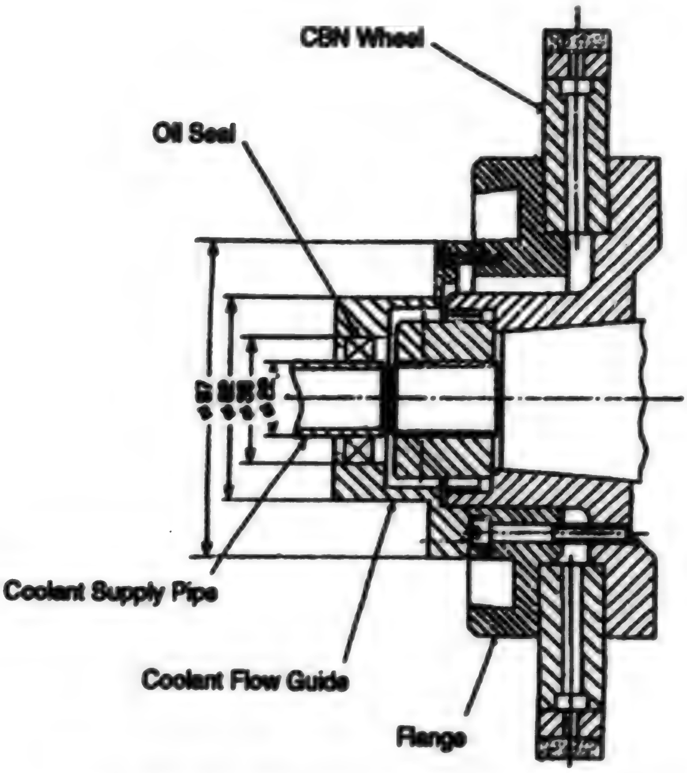


Figure 16: New Through-Liquid CBN Wheel Fitting Structure

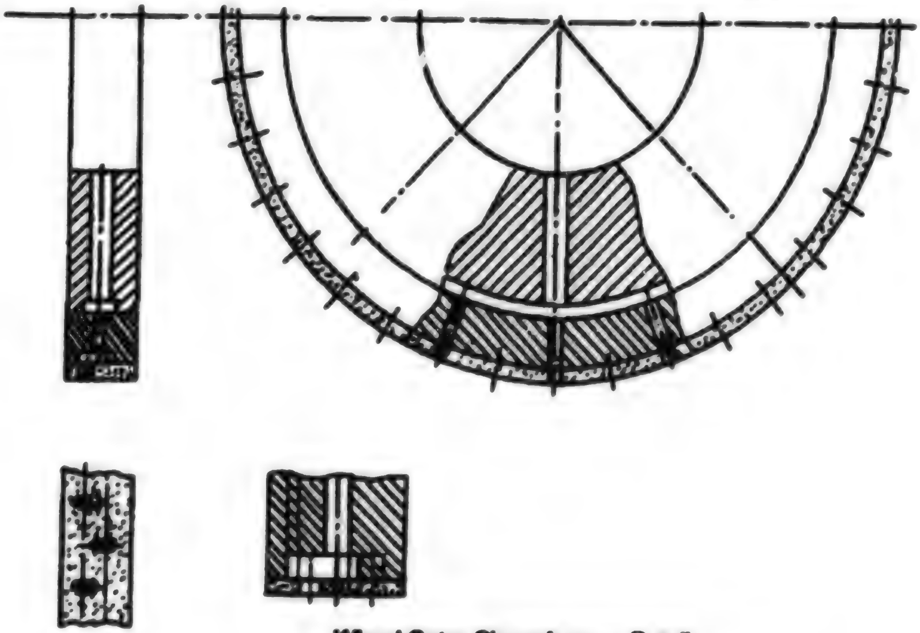


Figure 17: New Outer Surface Through-Liquid CBN Wheel

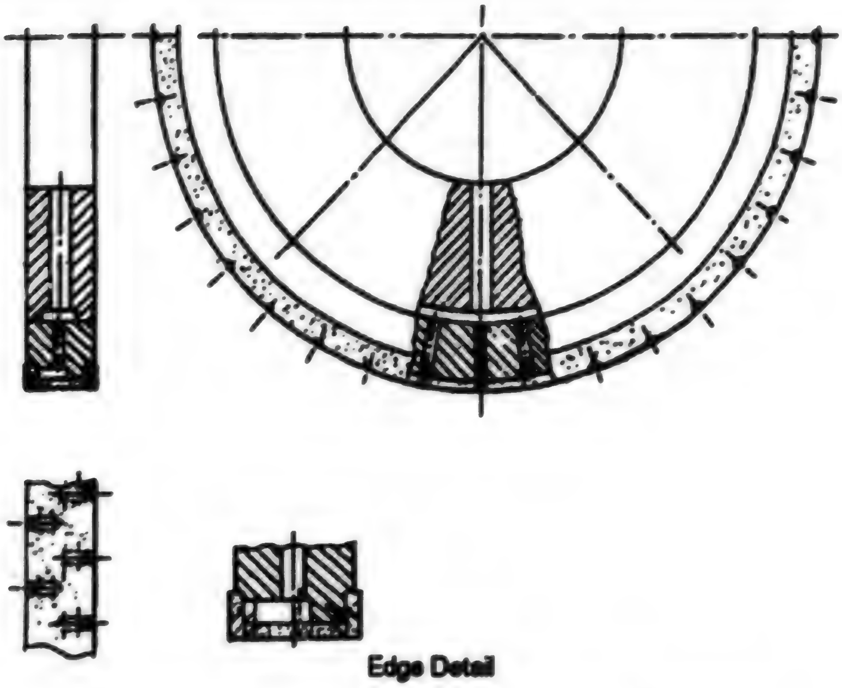


Figure 18: New Both-Edge Through-Liquid CBN Wheel

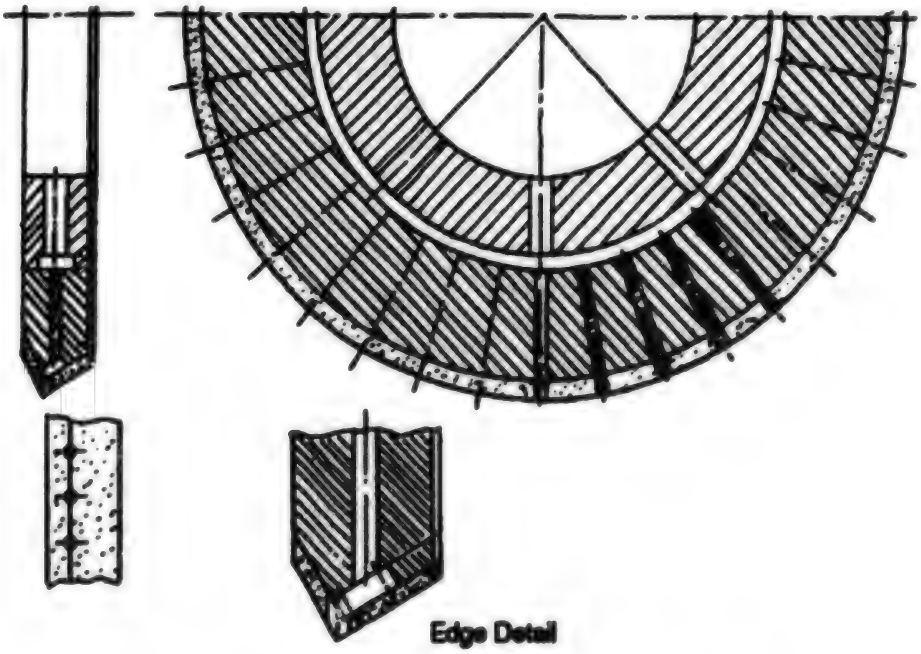


Figure 19: New Through-Liquid CBN Angular Wheel

Due to collapse caused by centrifugal force, these set-ups cannot be used for super high-speed grinding. Two alternatives must be used for super high-speed grinding: Divide the wheel into left and right, then make a groove in the radial direction on the contact surface; or cut a spiral groove in the wheel side surface and use it along with the wound nozzle, as mentioned in the preceding section.

Additionally, when supplying coolant with these CBN wheels, immersion type MGF-3 coolant is several times more effective for reducing wear and improving grinding performance. Care is needed when using solution type coolant supplying because it increases wearing by thermal shock and reduces grinding performance.

Reference

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Refractory Composite Materials for Rocket Vehicles

95FE0148B Tokyo CERAMICS JAPAN in Japanese Nov 94 pp 993-996

[Article by Shigekazu Higuchi, First Space Technology Division, Aerospace Business Department, Nissan Motor Corporation]

[FBIS Translated Text]

Refractory Composite Materials for Rocket Vehicles

1. Foreword

Successful launch of the H-II Rocket added the element of feasibility to R&D on the H-II rocket-launched winged recovery spacecraft (H-II Orbiting Plane, HOPE), which has been advanced by the National Space Development Agency (NASDA) since 1985, and recently, discussion of spaceplanes, represented by the HOPE, has become lively.

HOPE is a space transport system that is scheduled to be put to practical use at the beginning of the 21st century, and its goals and significance are as follows:

(1) Transport and recovery of supplies and goods to and from the Japan Experimental Module (JEM) of the Space Station.

(2) Japan's independent means to use the space environment for space experiments and observation.

(3) Advancement of independent Japanese development of space technology and accumulation of basic technology for the development of the Space Plane.

It would be no exaggeration to say that the key to successful development of the HOPE lies in the development of thermal structural materials and heat protection systems as well as the development of guidance and control technology. In the development of thermal structural materials and heat protection systems, it is desirable to develop recyclable refractory material that can withstand the severe aerodynamic heating (maximum temperature of heated surfaces will be 1,700°C; the nose cone and leading edge of the main wings) to which the HOPE will be subjected when it reenters the atmosphere.

Research thus far has created prospects for the development of refractory material for HOPE's thermal structural material and heat protection system. This article is a summary account of the development of advanced carbon carbon (ACC) for use in parts of HOPE's thermal structure and heat protection system that will reach a high surface temperature (over 700 to 800°C).

2. What Is ACC

Carbon/carbon composite material (C/C) was first developed in the United States. It is a material that can also be called fiber-reinforced graphite, in which graphite fibers are solidified in a graphite matrix. It can be used as a high-temperature strength material because in addition to having graphite's superior heat resistance, it is also reinforced by fibers.

In Japan, NASDA contracted Nissan Motor Corporation to develop the production of C/C with these properties for use in the nozzle skirt section of the apogee kick motor (AKM) that was mounted on the H-I Rocket. This was the first time in Japan that C/C was used in a rocket, as shown in Figure 1.

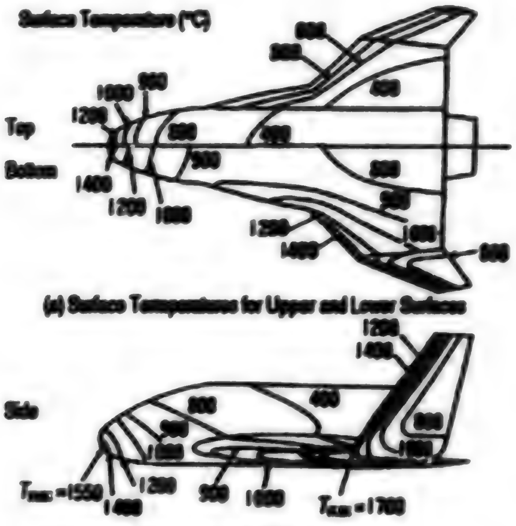
Figure 1: AKM for H-1 Rocket

ACC is an advanced version of C/C. Here, ACC means C/C that has the following special features:

(1) As the primary structural material for HOPE's nose cone and wing leading edges, it has adequate strength and hardness to withstand dynamic pressure during reentry.

(2) Because it is a carbon material, oxidation in a high-temperature oxidation atmosphere causes deterioration of C/C. Therefore, an antioxidation coating is provided to withstand the aerodynamic heating environment to which HOPE will be subjected during reentry into the atmosphere.

Figure 2 shows the estimated surface temperatures of the HOPE vehicle during reentry which are currently being studied. Figure 3 shows one proposal for materials to be used for vehicle surfaces as heat protection from the surface temperatures given in Figure 2.



(a) Surface Temperatures for Upper and Lower Surfaces

(b) Surface Temperatures for Side Surfaces

Figure 2: Surface Temperatures (°C) for HOPE Vehicle During Reentry (Angle of Inclination 40°, Altitude 40 km, Speed M-20)

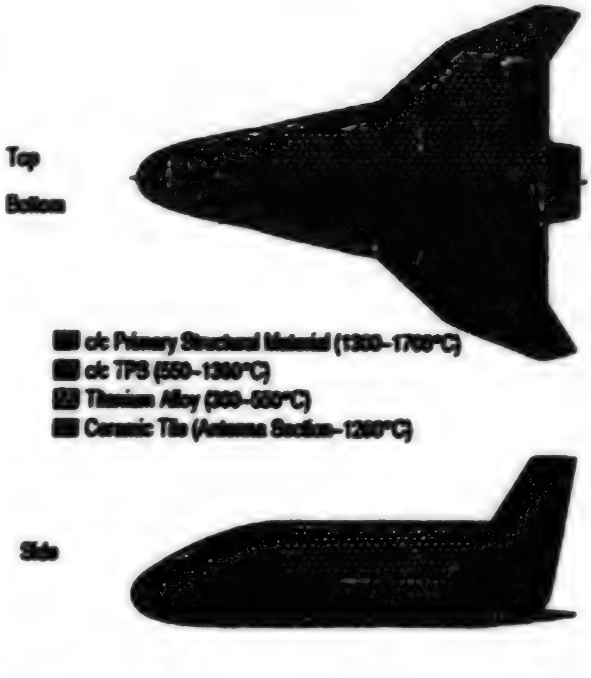


Figure 3: Example of Materials on HOPE Vehicle Surface

3. Production Methods

3.1 ACC Base Material Production Methods

There are three typical methods for manufacturing C/C, which are shown in Table 1.

Table 1. Typical C/C Manufacturing Methods

Method	Method Summary	Features
Resin Char Method	Carbon/phenol compact is heated, then more pitch is filled in and compact is reheated. This cycle is repeated several times.	Merits: Process, equipment are relatively simple; existing FRP manufacturing technology can be used. Demerits: Raising to high density is difficult; serious internal warping during initial baking causes cracks.
CVD Method	High-temperature thermal cracking of hydrocarbon gas produces carbon in a molecular state; vapor deposition of this carbon onto graphite fibers, the reinforcing agent.	Merits: Resistant to formation of large internal cracks, so high density is achievable; superior resistance to wearing. Demerit: Tendency for internal holes to remain, making uniform carbon vapor deposition difficult.
Combination Method	Produce low-density C/C by resin char method, then vapor deposition of carbon onto it by CVD method	Merit: Has the merits of both methods, no internal holes and high density is achievable. Demerits: Process is complex; equipment cost is high.

ACC is used for the nose cone, wing leading edges and other large, complex-shaped primary structural parts as well as C/C panel ribs and lap joint sections. The resin char method was adopted as the most appropriate method to use to manufacture these parts. As shown in Figure 4, this method is composed of the following processes: The process of manufacturing an FRP compact called a preform with a prepreg of carbon cloth impregnated with phenol resin; a carbonization/graphitization process in which the preform is baked to graphitize the resin; and a process to create high density, in which pitch impregnation through holes created by gasification in the carbonization/graphitization process is repeated with carbonization and graphitization.

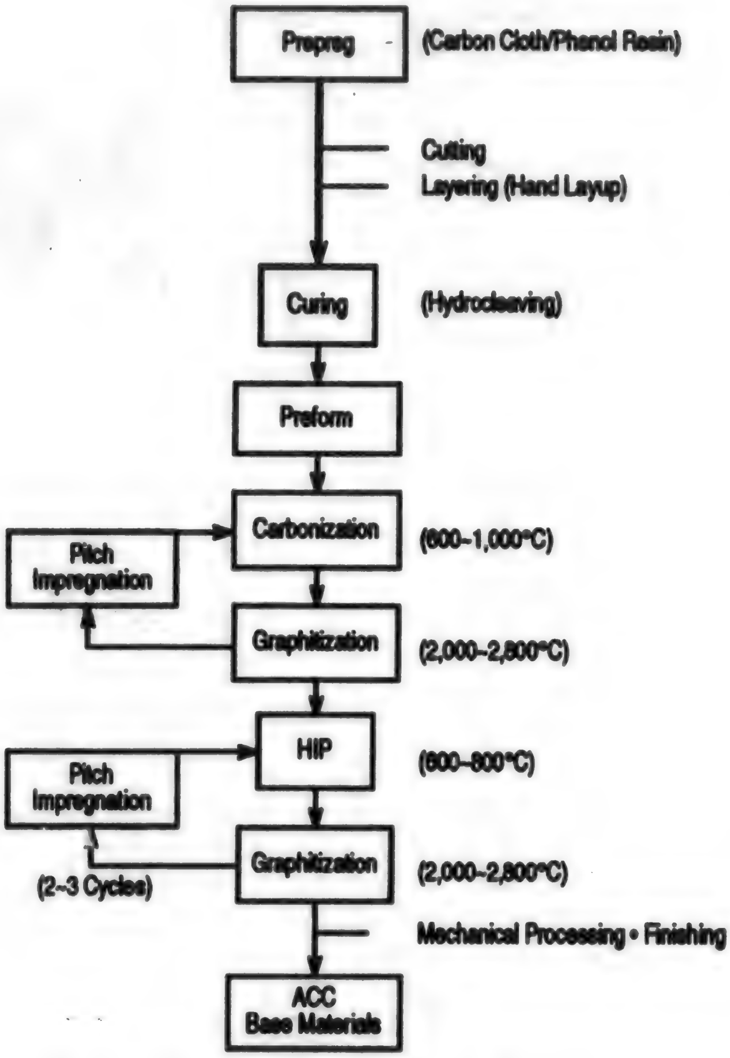


Figure 4: ACC Base Material Manufacturing Processes

The carbon cloth used must ensure a good balance between shaping capability of ACC and strength and hardness as a C/C, and fiber with a high rate of emergence must be used. Also, the process to create high density is essential in raising the rate of emergence of reinforcing fiber with C/C materials in general. Nissan used hot isostatic pressing (HIP) in this process, and improved the actual carbon ratio of the impregnated pitch. This made it possible to raise the density and improve strength and flexibility with few repetitions of the cycle of pitch impregnation, carbonization and graphitization. Figure 5 is a test-manufactured simulated nose cone.

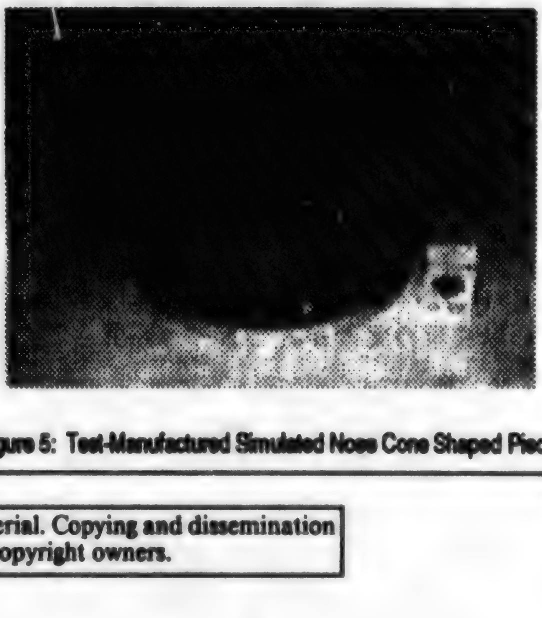


Figure 5: Test-Manufactured Simulated Nose Cone Shaped Piece

3.2 Antioxidation Coating

The base of the antioxidation coating of the ACC is an SiC coating that can withstand an oxidation atmosphere of 1,700°C. This is because, generally, SiC forms an

oxidizing zone of SiO_2in a high-temperature oxidation atmosphere, which prevents oxidation of the SiC, and its antioxidation capability can be used up to the 1,700°C level.

The antioxidation coating system with SiC as its base is composed of the following layers: an SiC diffusion layer as a graded layer to ease stress caused by the difference in thermal expansion between the ACC base material and the SiC coating layer; an SiC-CVD layer with stable antioxidation surface smoothing capabilities as well as the film thickness required for repeated use; and a glass sealing layer made by impregnating and softening under high temperature the microcracks on the surface caused by thermal expansion difference between the ACC base material and SiC coating layer, which will prevent oxidation caused by oxygen attack from the microcracks. Figure 6 is a cross-sectional SEM photograph (Si formation image) of a product in which an antioxidation layer was placed on the ACC base material. It shows that the SiC diffusion layer has diffused into the ACC base material and is functioning as a layer that eases stress caused by thermal expansion difference between the SiC-CVD layer and the ACC base material.

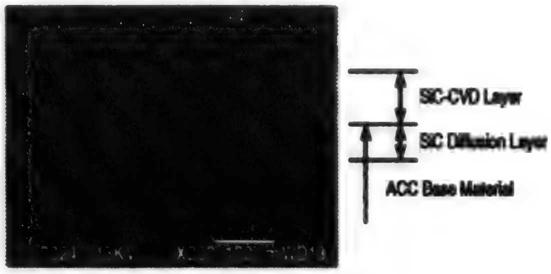


Figure 6: Product with Cross-Sectional SEM Photograph of ACC Antioxidation Coating (Si Formation Image)

4. Material Characteristics

Table 2 gives the mechanical properties at room temperature of the test-manufactured ACC. Additionally, the ACC has the same tendency as regular graphite of increased strength and flexibility at high temperatures.

Table 2. ACC Characteristics

Temperature (°C)	Room Temperature		1000		1700	
SiC Coating:	Yes	No	Yes	No	Yes	No
Tensile Strength (MPa)	314.5					
Tensile Strength (GPa)	165.6					
Flexural Strength (MPa)	346.9	266.6	374.4	330.3	497.8	443.9
Flexural Strength (GPa)	128.4	111.7	150.9	157.8	149.9	224.4
Compressive Strength (MPa)	151.9	226.4				
Compressive Strength (GPa)	124.5	160.7				
Interlayer Shear Strength (MPa)	10.8	12.5				
Bulk Density ($10^3 kg/m^3$)		1.85				
Apparent Density ($10^3 kg/m^3$)		1.98				
Porosity (%)		7.06				

Figure 7 is an example of an antioxidation characteristics evaluation test. It shows the state of a simulated leading edge-shaped product with antioxidation coating after a 1,300°C x 10 cycle test (atmospheric), and confirms that both the ACC base material and the antioxidation coating system are sound.

In addition, Figures 8 and 9 are optical microscope photographs of the surface of a sample before and after an arc heating wind tunnel test (1,700°C x 1,100 seconds) that simulated the heat environment conditions during HOPE's reentry. In Figure 9, it is seen that even after the arc heating wind tunnel test, the glass sealing material remains in the microcracks; no defects, such as oxidation of the ACC base material, or peeling or major receding of the SiC coating layer, could be detected; there is evidence that the glass sealing on the surface and in the microcracks have softened; and it can be confirmed that the functions are being fully carried out.

Figure 7: High-Temperature Oxidation Cycle Test (1,300°C x 10 Cycles) (Test-Manufactured Simulated Leading Edge Shaped Piece)

It is therefore believed that ACC base material strength and antioxidation capability completely fulfill the ACC material requirements for the HOPE.

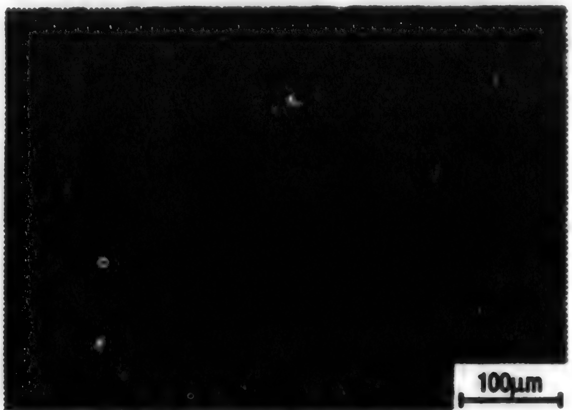


Figure 8: Optical Microscope Photograph of Sample Surface Before ACC Arc Heating Wind Tunnel Test

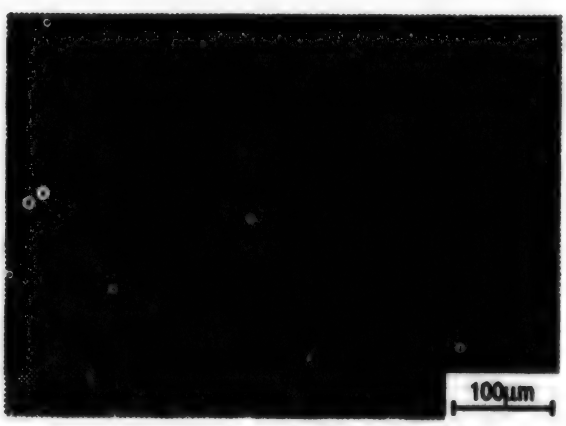


Figure 9: Optical Microscope Photograph of Sample Surface After ACC Arc Heating Wind Tunnel Test

5. Postscript

As stated in this summary account of ACC material development, it is believed that use of ACC materials in spaceplanes, which are represented by the HOPE, will be realized soon. Henceforth, R&D will focus on improving product reliability and achieving more advanced performance. Incidentally, this research is being carried out as part of NASDA's "research on refractory structure technology."

Supermetal R&D Trends

95FE0150A Tokyo KIKAI SHINKO in Japanese Aug 94 pp 38-43

[Article by Toshihiro Hayashi, principal director, Next-Generation Metals and Composite Materials R&D Association]

[FBIS Excerpt]

Supermetal R&D Trends: Amorphous, Nano-structure Controlled Materials

Foreword

With technological advancement, the environment in which materials are used in sectors such as aircraft, space and thermal power generation has become increasingly harsh, while at the same time, society demands conservation of energy and resources. Therefore, the recent trend is to demand materials that are light, strong, easily recyclable, and more reliable.

New ceramic and plastic materials have been developed to meet such demands, but there are many areas where only metal will do. Particularly in the field of structural materials, expectations concerning metallic materials continue to be strong and development of new materials with capabilities exceeding those of existing materials is being sought.

A variety of research is being conducted in search of superior materials that meet the needs of various fields. In this article, we will look at R&D trends concerning amorphous and nano-structure controlled materials as "supermetals" that are likely to overcome the limitations of existing metallic materials.

(1) Background of R&D

The history of metals is long and extends back to ancient times. Even after the industrial revolution, manufacturing processes and material properties were improved to fit the needs of the times, such as major development of iron and steel materials beginning in the 19th century and great strides in the development of aluminum alloys as an aircraft construction material in this century.

Because Japan's aircraft industry was slow in developing after the war, Japan's advanced metallic materials were not among the world's best. To catch up, the theme of "high-performance crystal controlled alloys" was included in the FY81 next-generation basic industrial technology R&D system of MITI's Agency of Industrial Science and Technology (AIST), and R&D was carried out for eight years. "High-performance crystal controlled alloy" is not an often-heard phrase, but the goal was to improve material properties by controlling not just the composition of the alloy but the crystal state of the alloy through various processes. The properties of metals or alloys are greatly affected by their components as well as

their minute crystal structure. In the case of manufacturing of materials, control of crystal structure does not extend to picking up single atoms, which are the elements of composition of the material, and putting them in the desired spot. It must boil down to using manufacturing and fabrication processes to manipulate the crystal state of alloys toward the desired goal. In recent years, a variety of new manufacturing and fabrication processes have been conceived and put to practical use to make this possible.

Through R&D projects under the theme of "high-performance crystal controlled alloys," a nickel-base super heat-resistant alloy and superplastic alloy as well as a titanium-base superplastic alloy were developed as materials for aircraft engine turbine blades and turbine disks, resulting in great strides toward approaching the world's best materials in this field.

Next, through eight-year projects under "super environment-resistant advanced materials," which began in FY89, advanced composite materials such as carbon fiber-reinforced carbon base metal (C/C) and intermetallic compounds such as TiAl and Nb_3Al were the targets of R&D. At present, R&D is progressing on lightweight, high-temperature strength structural materials for use in building the fuselage or engine of the ultra-supersonic aircraft and the spaceplane, which are expected to be realized at the start of the 21st century.

The theme of this R&D is to make heat-resistant structural materials out of intermetallic compounds, which until now have only been used as functional materials, and something that is quite close to that goal is already being developed. This R&D is highly significant because it addresses the unexploited area of using materials that are brittle and difficult to shape in the same way as structural materials, and is aimed at improving mechanical qualities through alloy design and processing.

The above are examples of recent material development, but most material development thus far has been achieved either by processes such as heat treatment or by varying the amount of elements added during alloying. In terms of the crystal structure of material, crystal particle size was at the micron level at most. For this reason, although some functional characteristics such as super-plasticity were manifested, characteristics peculiar to a substance were not reflected in their original form in the characteristics of the resulting material. This was mainly because the multiple structural faults that existed on the crystal particle boundaries had killed almost all of the qualities peculiar to the substance.

Recently, however, it has become known that creating a microstructure of crystal particles at the nanometer level, which is a thousandth of a micron, enables remarkable improvement of material properties. It is believed that this is because structures composed of crystal particles whose diameters fall between the nanometer and 100 nanometer range have almost no disarray of crystal structure originating in the particle boundaries, and have nearly perfect crystal structures. (See Figure 1.)

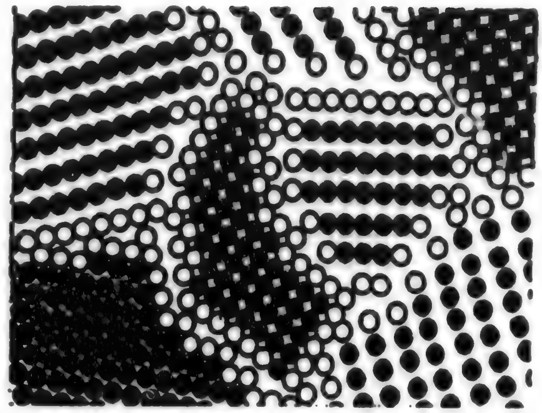


Figure 1: Image of Nano-crystals

Even in Japan, interest is growing in this nano-structure controlled material as the most highly advanced area of material science, and there is a great deal of research on artificial lattices, superparticles, etc. In recent years, a variety of different approaches have been tried, including research on making amorphous material in bulk form and formation of nano-scale, nonequilibrium amorphous substances by the mechanical alloying method.

These research projects are being carried out for various reasons and are not necessarily limited to nano-structure controlled materials, but it is believed that it is possible to deal with them together as a future trend.

(2) What Are Amorphous, Nano-structure Controlled Materials

Almost all existing metallic materials, including the intermetallic compounds mentioned in Section (1), are crystal materials composed of polycrystals. However, when molten alloys are super-quenched (10^4 to 10^7°C per second), they become so-called "amorphous" materials which have a random atom configuration rather than a crystal structure (see Figure 2).

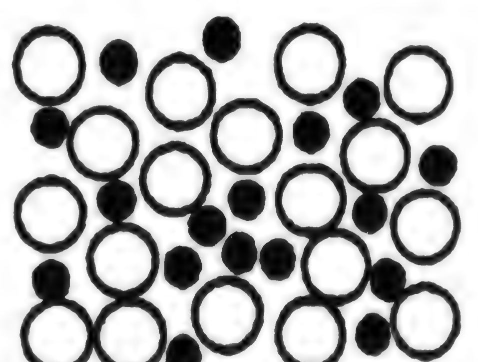


Figure 2: Amorphous (Super-Quench: 10^4~10^7 c/s)

These amorphous alloys are far superior to existing metallic materials in strength, durability and corrosion resistance, but until now have only been made in thin-belt, fine-line and particulate forms. In order to use amorphous alloys as structural materials, technological development that will make it possible to increase their bulk and form them into desired shapes is essential. Recently, that possibility has emerged.

It is also known that when nanometer size crystals are deposited during the amorphous mother phase, strength and other mechanical properties are improved and excellent values more than three times that of existing materials are exhibited.

An example of the effects of non-crystal structure control is the TiAl intermetallic alloy that was unveiled in the United States. The relationship between its mechanical properties (hardness) and crystal size is that hardness increases as crystal size is increased until it peaks when crystal size is 25 nanometers, and decreases thereafter. At its peak, hardness is close to four times that of normal casting.

Recent research such as this has brought to the forefront next-generation metallic material R&D themes such as bulk amorphous materials derived from liquid quenching or mechanical alloying, nano-structure controlled materials composed of nanometer size crystal particles, and nano-structure controlled composite materials created by reducing metallic and nonmetallic crystal particles to microscopic size and then combining them.

Now, how are amorphous and nano-structure controlled materials made? The basic manufacturing process involves powdering and then sintering and solidifying the powder. In addition to this, research is being done on methods such as manufacturing of bulk material by agitation and coagulation and the method of layering multiple films onto a substrate by vapor condensation.

Furthermore, through formation processes, bulk amorphous metal has been created recently at cooling speeds below the 10^{4}°C per second needed to achieve the amorphous state. Research conducted by Akihisa Inoue, an instructor at Tohoku University, claims that it is possible to cast amorphous material in rod form at cooling speeds of about 10^{2}°C to 10^{3}°C per second.

There are two powder manufacturing processes. One is the super quenching and coagulation method, in which molten metal is super-quenched so that a substance that normally would be a solid with a crystal structure is powdered while still in an amorphous state or in nanocrystal form, which does not allow crystal growth. The other is mechanical alloying, in which amorphous alloys or nanocrystal powders are manufactured by placing a variety of metallic powders in a ball mill and shaking them at normal or high temperature, which forcibly mixes and refines them.

Next, to solidify the powder by sintering, it is necessary to solidify the powder by heating it for a very short length of time to prevent crystal growth or coarsening during solidification. In addition to the existing method of HIP (hot isostatic pressing), research is being conducted on new methods in which solidification is achieved by plasma sintering or electric discharge sintering.

In addition, the agitation and coagulation process controls homogeneity of ingredients and crystal structure by using a rotator for agitation while the alloy coagulates. Therefore, in addition to amorphous and nanocrystal material, it can also be applied to the manufacturing of particle dispersion reinforced composite material, for which these are matrices.

Finally, vapor condensation uses sputtering to form thin films on a substrate. This simplifies the compounding, layering and gradation of the material and enables the creation of amorphous or nanocrystal material.

As for areas of use, due to their lightness and high strength, amorphous and nano-structure controlled materials can be used as materials for fuselages or engines in the aircraft and space sectors. In the future, once the cost goes down, these materials can also be used as lightweight, high-strength materials for automobiles and industrial machinery, especially for equipment such as air conditioner compressors. They can also be expected to increase the life of rotating parts and help conserve energy. Recycling also should be easily accomplished because they have fewer added elements than existing alloys.

Moreover, it is possible that the process of creating amorphous or nano-structure controlled materials will enable the development of materials with very unique functional characteristics. In addition to soft magnetic material, which has already been put to practical use, research is being conducted on a variety of uses such as biomaterial and damping material, and development is expected. (See Figure 3 and Table 1.)

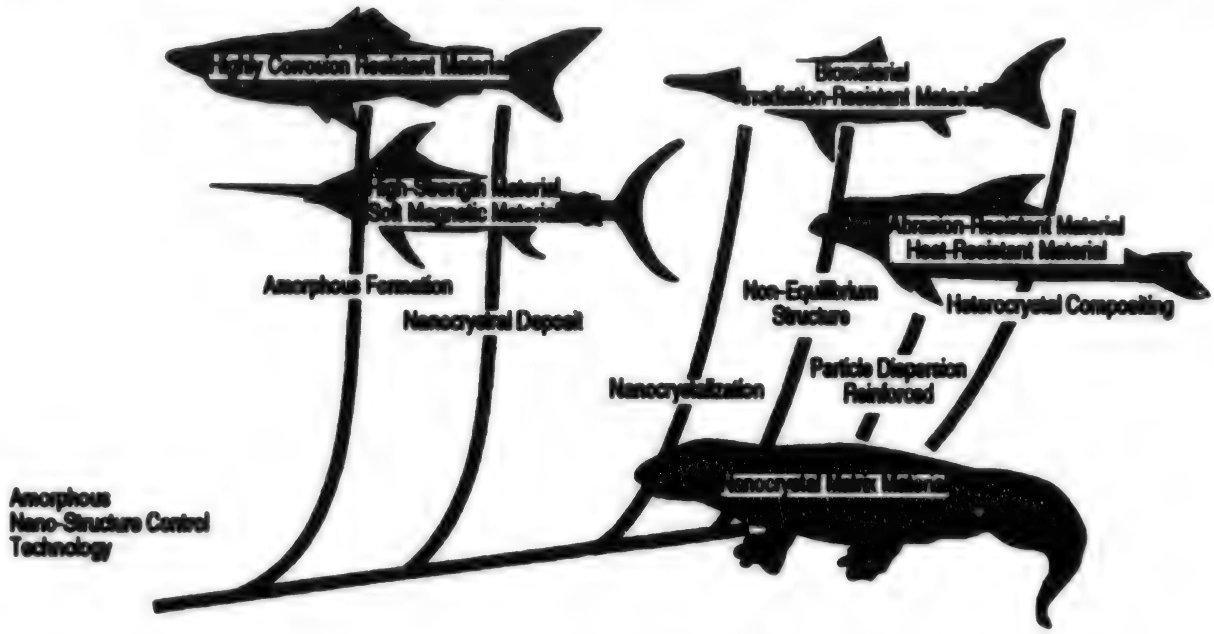


Figure 3: Amorphous/Nano-Structure Controlled Mettalic Materials and Explanation of Structure Control Technology

Table 1. Development of Amorphous, Nano-Structure Controlled Materials

Item	Research Topic	Analysis Equipment	Process	Application
Study, Control of Amorphous/Nano-Structure, Boundary	Junction surface activation Low-temperature junction technology	STEM	Nano-wafer	Junction with no heat-affected part in nuclear energy equipment
Study, Control of Bulk Structure	Amorphous metal material Nanocrystal dispersion reinforced amorphous structure material Nano-structure controlled material Nano-structure controlled composite material	ESCA STEM	Quench casting Mechanical alloying Extrusion, rolling Even heat annealing Recrystallization induction	Soft magnetic material Heat resistant component for gas turbine, etc. Lightweight, high-strength material
Study, Control of Transformation Mechanism	Superplastic damping material High-ductility intermetallic compounds	STEM Atom probe	Mechanical alloying, layering Quench casting, processing	Room temperature superplastic damping material Heat-resistant component for gas turbine, etc.
Study, Control of Environment-Adaptiveness, Deterioration	Environment-adaptive material	ESCA STEM Electrochemical testing equipment	Ion implantation Cladding, potential control	Bio-adaptive material Inorganic bonding material Artificial bones, dental roots Corrosion-resistant material
	Creep deterioration, life estimate Measurement of atom segregation at deposit boundary			Heat transfer, heat-resistant material
	Life extension, surface reforming/cladding Identification of amorphous/nano-structure of powder produced by abrasion	Atom probe STEM	Surface reforming Surface cladding	Tribology material Sliding component for rotating equipment Abrasion-resistant material

(3) Trends in Japan

Next, let us look at amorphous material and nanocrystal material R&D trends in Japan.

With regard to amorphous material, the technology for liquid quenching by the single roll method was already established by the beginning of the 1970s. In the latter half of the 1970s, interest became focused on the fact that amorphous alloys exhibited excellent soft magnetic qualities, and the universities and private companies began energetic R&D on this dream material.

So far, amorphous material has been used almost exclusively as magnetic material, such as the core material for transformers, magnetic heads for audio equipment, and magnetic sensors. Lively R&D in this sector is continuing.

In the latter half of the 1980s, interest became focused on the fact that non-equilibrium phase substances such as amorphous alloys and nanocrystal materials could be created through mechanical alloying, a method using solid phase reaction, and R&D activity became lively.

As for nanocrystal material research, in the 1980s, Gleiter of Zahrant University in Germany reduced crystal size to the microscopic nanometer level and announced that materials in which the proportion of particle boundary has been increased exhibit properties (thermal expansion, density, strength, magnetism) that existing materials did not have. This drew a great deal of attention, and research flourished in every country.

In Japan, the "super-particle research project" was taken up in the innovative science and technology promotion system of the New Energy and Industrial Technology Development Organization, and research was conducted from 1981 to 1986. The goal of this project was to create super-particles and to study their properties; it did not cover nanocrystal materials which are made from super-particle powder. Nevertheless, this was the most advanced research on super-particle properties and manufacturing methods at the time, and the "gas evaporation method" for manufacturing super-particles that resulted from this research has come to be used by many researchers all over the world.

Research on nanocrystal material continued after Gleiter's announcement because of scientific interest about its unique properties. Recently, however, with the emergence of the possibility of developing it as an industrial material, R&D leading to practical application has been observed in Japan, the United States and Europe.

In Japan, in recent years, several excellent projects have been underway at various universities. In addition to the research mentioned in Section (2) by Tohoku University's Akihisa Inoue on bulk amorphous metal and nanocrystal material, there is research on nanocrystal boundaries by Yoichi Ishida of Tokyo University, research on a new mechanical alloying process to replace the ball mill by Kyoto University's Hideo Shingu, and metal cluster research by Tohoku University's Kenji Sumiyama.

As stated earlier, private industry used amorphous materials in the field of magnetic materials some time ago, but application in fields such as structural material has just begun, and industrial use is a matter to be addressed in the future. Some experimentation has been seen recently.

One example is experimentation with making bulk material from (1) amorphous materials with aluminum or magnesium base that have completely different compositions from aluminum or magnesium alloys, or (2) materials in which nanocrystals were deposited from their amorphous phase. Research is being done on the possibilities for use as lightweight and high-strength shaping material or machine parts.

In addition, other research projects that have been observed involve use of amorphous materials as biomaterials or superplastic dampers to prevent earthquake vibration of pipe systems, and research on development of superior corrosion-resistant and abrasion-resistant material through amorphous and nano-structure control.

(4) Overseas Trends [passage omitted]

Conclusion

In the past, metal alloys have been made in electrical furnaces and improvement of their material properties has been attempted through adjusting the number of added elements, reducing impurities, or additional processing and heat treatment. These methods to improve material properties are reaching the limit, however. This is because structural control was limited to the micron level. It is believed that significant improvement of material properties will be possible if this is advanced to the nanometer level so that the properties of the metals themselves can be demonstrated.

To accomplish this, analysis and evaluation at the atomic level and the establishment of theories about the phenomena are needed. This approach became possible when improvement of the precision of the electron microscope made the dispersion of atoms visible. This kind of control at the atomic level is already being done in fields such as semiconductor manufacturing processes, but is only beginning to take root in the field of structural materials. If this is carefully nurtured, it can be expected to have great impact on the materials and machine industries.

Studies are being advanced by AIST, but cooperation among industry, academia and the government is desirable for the following reasons: (1) there is excellent research experience on this theme in Japan; (2) Japan already has most of the elemental technologies; and (3) it is one of the goals of refinement of metallic materials.

Research on amorphous and nano-structure controlled materials has recently grown lively all over the world, but it is still in its early stages, and many unexplored regions, beginning with theoretical understanding of their unique properties, lie ahead. It is hoped that this will be fully developed in Japan as original, innovative Japanese research based on an academic foundation.

NASDA, ESA To Cooperate on Optical Intersatellite Communication Tests

95P60087A Tokyo NIKKEI SANGYO SHIMBUN in Japanese 9 Dec 94 p 5

[FBIS Translated Text] The National Space Development Agency (NASDA) and the European Space Agency (ESA) signed a Memorandum of Understanding on 8 December in Paris after they agreed to cooperate on optical communication experiments through satellites. The experiments will include maintenance, tracking and optical communications between the optical intersatellite communication engineering test satellite (OICETS), which NASDA is scheduled to launch early in 1998, and the communication test satellite "ARTEMIS" which ESA is scheduled to launch in 1997. It is reportedly the first cooperation effort between Japan and Europe in the field of intersatellite communications.

With laser beams for satellite tracking and communication equipment for "S-band" high frequency on board, OICETS will travel in low earth orbit of several hundred kilometers in altitude. Its objective is to confirm the basic technology necessary to efficiently transmit to earth data obtained by earth observation satellites. ARTEMIS, on the other hand, will circle in a geostationary orbit 36,000 kilometers high. Europe responded to Japan's request for cooperation with the experiments since commercialization of high speed and large volume communications for future space activities is being sought.

Optical communications allows a relatively small device to handle a great deal of information. However, line-of-sight transmission of light beams makes the maintenance and tracking of the satellites difficult, and therefore they have been important subjects for research and development.

NASDA To Start Basic Design of ADEOS-II

95P60087B Tokyo KAGAKU KOGYO NIPPO in Japanese 13 Jan 95 p 1

[FBIS Translated Text] The National Space Development Agency (NASDA) in FY95 will start official development of the Advanced Earth Observing Satellite "ADEOS-II" which observes the globe's water and energy circulation. ¥7.7 billion, the amount required to upgrade from the research to the "development" phase, has been included in the FY95 government budget proposal. During this development phase, basic and detailed design work and creation of models will be undertaken to prepare for the launch of the major "H-2" Japanese rocket scheduled for the winter of FY98.

Changes in the global environment such as global warming are thought to be closely related to the circulation of water and energy between the oceans and the atmosphere. The ADEOS-II satellite is designed exclusively for earth observation. It will gather the earth science data necessary to understand the mechanism of global-scale water and energy circulation. It provides observations considered essential for research on global environmental issues. It will replace the earth observation platform engineering test satellite "ADEOS" which is scheduled for launch in the winter of FY95.

ADEOS-II will be equipped through internationally cooperative arrangements with five sensors which will capture wide-scale movements of the global environment. NASDA will install a next-generation passive optical sensor (GLI) which can observe a wide range of the atmosphere, temperature and land, and an advanced microwave sensor (AMS) which can measure ocean surface temperatures, water vapor content of the atmosphere, and the amount of precipitation.

In addition, the Environment Agency will install an improved atmospheric marginal infrared spectrometer (ILAS-II) which can measure minor components (ozone, aerosol, etc.) of the atmosphere. Among overseas participants, NASA's "SeaWinds" which can measure ocean wind velocity and direction and the French National Space Development Center's "POLDER" which can measure polarization and polarity of solar beams reflected by the earth's surface and atmosphere will be installed.

R&D will begin in FY94. The research phase will be upgraded in FY95 to officially start "development." According to the Science and Technology Agency, basic design work will begin in FY95. Detailed design work will follow soon after and production that includes creation of the engineering model, proto flight model, and flight model will occur.

Power Generation Reduction Within Estimate

95P60087C Tokyo KAGAKU KOGYO NIPPO in Japanese 12 Jan 95 p 12

[FBIS Translated Text]

NASDA Reports Kiku-6 Operation Update

The National Space Development Agency (NASDA) on 10 January reported on the latest situation of Japan's first 2-ton engineering test satellite "Kiku-6" which had been launched to conduct advanced satellite communication experiments and confirm the bus technology necessary to develop high performance commercial satellites.

According to NASDA, the solar cell paddle's power reduction caused by the Van Allen belts continues and the present capacity is approximately 3,100 Watts. This is within the range estimated in December 1994 and said to be the level at which various experiments can be conducted.

On 5 January, it was confirmed that the satellite's attitude has been shifted from triaxial attitude control mode to sun directing mode. On the following day, NASDA reestablished the triaxial attitude, but when the malfunction detection function was actuated, once again the sun directing mode was restored. NASDA assumes that was caused by an error made in the commands given for satellite control which are stored in the satellite computer memory. On 9 January, the work necessary to return to the triaxial attitude once again was carried out and it is now transforming to ordinary mode.

Development of Gas-Turbine-Coal Fired Hybrid Power Generation System

95FE0195A Tokyo KAGAKU KOGYO NIPPO in Japanese 1 Dec 94 p 16

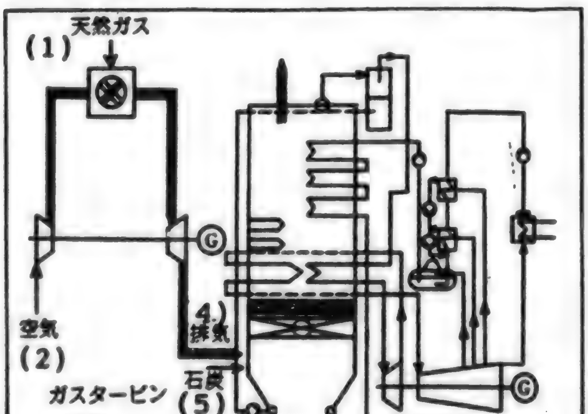
[FBIS Translated Text] A more specific concept of a gas-turbine-coal-fired hybrid power generation system, for which expectations run high because it uses coal to achieve high efficiency, is emerging. According to trial calculations recently performed, the output of this system, which combines a natural-gas-fueled turbine and a fluid-bed coal boiler, is 405.9MW, attaining an overall efficiency of 51.2 percent. Ken Shibata, professor of Shibaura Institute of Technology and chairman of Japan Cogeneration Research Association, who is promoting this concept said, "China should use natural gas while Japan, equipped with advanced technical capability, should use coal in the high tech field." This presents steel companies with the opportunity to enter wholesale power generation business, as regulatory control for power generation has been eased somewhat.

Chance for Commercialization for Steel Industry

The gas turbine-coal firing hybrid power generation is based on a mixed combustion cycle involving a gas turbine fueled by natural gas and a fluid-bed coal boiler which uses exhausts produced by combustion occurring in a gas turbine. The combustion efficiency obtained by this method was 35 percent when a 224.5MW gas turbine was used and 33.3 percent when a steam turbine was used. For plant's electricity output of 405.9MW, fuel input was 792.2MW, which means an overall efficiency was 51.2 percent.

The temperature of fluid-bed coal boiler's air exhaust temperature is 122°C, and a large portion of natural gas's energy is effectively used by the boiler, thus improving overall efficiency. The temperature of gas at the gas turbine inlet was 1223.5°C and pressure was 15 bars. As for the high pressure steam turbine, its temperature was set at 535°C and pressure at 195 bars, while the temperature and pressure of the low pressure turbine were set at the same temperature and pressure at 42 bars.

Gas Turbine-Fluid Bed Coal Boiler Hybrid Thermal Power



Key: 1. Natural gas 2. Air 3. Gas turbine 4. Air exhaust 5. Coal 6. Fluid-bed coal boiler 7. Steam turbine

For some time, Professor Hirata has been focusing his attention to the coal-related infrastructures which do not require steel companies and maintained that coal should be effectively utilized as the electricity source. Moreover, since it is possible to obtain energy efficiency of over 50 percent by combining it with a gas turbine, he maintains that it contributes to acid rain preventive measures.

Construction of a natural gas-coal hybrid thermal power plant will be completed in Ulm City in Germany. This plant is equipped with a 60.3MW capacity gas turbine and combines a waste heat recovery boiler and a coal boiler. Coal boiler's steam is "superheated" by the waste heat boiler. After it has been used to rotate the steam turbine, the steam will be used to supply heat to the region. When regional heat supply is zero, the steam turbine's output is 348.7MW. When 280MW (thermal output) is used to supply heat to the region, 303.5MW electricity will be generated.

MITI To Begin Development of CALS System for Power Generation Plants

95FE0195B Tokyo NIHON KEIZAI SHIMBUN in Japanese 16 Dec 94 p 7

[FBIS Translated Text] In March 1995, MITI will begin developing an integrated Computer-Assisted Logistics Simulation (CALS) system for power generation plants linked by electronic networks. In addition, MITI and related industries have joined forces to organize a "committee on preparation for CALS Survey-Development Project," which will decide on how the development should proceed. Concluding that "in order to strengthen Japan's ability to compete, it is essential that our industries have advanced computerized information systems" (Machinery and Information Industries Bureau), MITI will take a next step, which is to construct a CALS model designed to serve as an effective tool for standardization of industrial information systems and establishment of rules.

CALS will computerize and network information contained in design drawings, business contracts, and user manuals so that useful data can be shared by network participants. CALS is expected to increase the efficiency level of production systems beyond the framework of companies and affiliated business groups.

The study committee has decided to establish by the end of March 1995 a technological research association involving MITI and a few tens of leading companies in the related industries, such as computer, electric power, and steel.

According to the plan, a section of a power plant, such as a boiler room, will be chosen and its processing model, beginning with design and development of parts, manufacturing, supply, through operation, will be constructed. When this has been completed, software will be developed so that users can access documents and drawings which they require through electronic networks.

Mitsubishi Material, MIT Begin Joint Research to Use Industrial Waste for Kiln Fuel

95FE0195C Tokyo NIHON KOGYO SHIMBUN in Japanese 27 Dec 94 p 1

[FBIS Translated Text] Mitsubishi Material and the Massachusetts Institute of Technology (MIT) have undertaken a joint research designed to utilize industrial waste for kiln fuel. The industrial wastes with which they will be dealing consist of shredder dust and vinyl chloride produced during wrecking of abandoned automobiles. Anticipating more extensive use of electronic devices in automobiles, which will increase the amount of gold and copper used, Mitsubishi will promote metal recovery and use of dust to produce fuel, thereby contributing to global environmental protection while creating a spin-off business for the company.

In order to participate in joint research and receive guidance, Mitsubishi Material's Cement Development Center (Yawata Minami Ward, Kita Khushu City) has already sent an engineer to MIT to study under Professor Julian Zachry. Another engineer will be sent around next fall. At MIT, using simulation, they will study behaviors of hazardous substances, such as chlorine gas generated when the type of waste, which is an unknown material, is used to produce fuel. Also studied will be the quantity of burned ashes which is allowed to be mixed into cement.

In the meantime, the company will conduct combustion testing using a kiln at a relatively small-scale Kurosaki Plant (Yawata Minami Ward, Kitakyushu City). They will carbonize plastics and vinyl chloride separated from shredder dust to remove toxic chlorine and then pulverize them before using them as kiln fuel. The burned ashes can be used as a cement material.

In the future, gold and copper will be recovered from shredder dust. Researchers also will attempt to isolate as much iron and aluminum as possible so that industrial waste, in this case smashed automobiles, can be completely reused.

The cement industry thus far has accepted as fuels waste tires and other industrial wastes which can be burned. Shredder dust and plastics which produce a toxic gas when burned, however, have been disposed at dumping sites. As it increasingly is becoming difficult to secure a dumping site year after year, reducing the volume of waste through incineration as well as utilization of burned ashes is considered highly desirable.

Kansai Electric Power Co. To Develop Laser Dielectric Technology to Protect Electric Lines

95FE0195D Tokyo DENKI SHIMBUN in Japanese 21 Dec 94 p 1

[FBIS Translated Text] On December 10, 1994, Kansai Electric Power Co. began a full-scale field experiment designed to achieve laser dielectric technology to protect electric lines. [Mt. Take] (200 meters above sea level) in Mihamamachi, Fukui Prefecture, provided the test site. A 1000-J capacity carbonic acid gas laser system and two 1-meter long-distance converging mirrors each measuring 50 cm in diameter are being used. This type of field test is said to be the world's first. By making an approximately 20-meter plasma on the upper part of the indirect lightning stroke tower's edge to pass lightning harmlessly to the tower.

The installed equipment consists of a main laser unit, two main discharge electric source units, and an electron gun power source unit. The field testing is designed to reflect two 20 million kW laser beams using two converging mirrors and to link them at the tip of indirect lightning stroke tower to produce plasma.

Lightning stroke causes two-thirds of overhead power transmission line service interruption. In the area served by Kansai Electric Power Co. alone, incidence of damage caused by lightning numbers from 700 to 800. The number of cases in which supply of electricity was interrupted was 11 (an average of the past five years). Laser dielectric technology is designed to guide lightning to a safe place before it strikes. If electric discharge paths can be controlled with precision, then it will be possible to protect electric lines from lightning. Currently, both electric industry and universities are pursuing research to achieve this. The principle of guiding lightning is based on ionization of nitrogen and oxygen molecules using laser beam energy and turning ionized molecules into a plasma state with positive charge thereby attracting lightning (electrons); and lightning paths are created by irradiating thunder clouds with pulse beams.

Since April 1990, Mitsubishi Materials Co. has been conducting research in laser dielectric method of inducing lightning jointly with Osaka University and Laser Technology Research Institute (Director: Mikio Kitada, vice president of Kansai Electric Power).

The company was successful in creating a bent-back Z-letter shaped discharge in an indoor test conducted in August 1991. In November 1992, by using a 100J capacity carbon dioxide gas laser equipment, it succeeded in generating an approximately 2-meter long plasma.

The test will continue until the end of January 1997. It will be conducted under various weather conditions focusing on wintertime thunder in order to securely establish laser dielectric technology designed to guide lightning through created paths.

In parallel to this research, the company plans to pursue a "thunder forecasting technology" research which is important in determining directions of laser irradiation and timing.

Toyohashi University of Technology Develops Desulfurization Technology Using Sea Shells

95FE0139A Tokyo NIKKAN KOGYO SHIMBUN in Japanese 31 Oct 94 p 4

[FBIS Translated Text] Nagoya—Professor Kazutomo Otake and Assistant Ichiro Naruse of the Ecological Engineering School, Toyohashi University of Technology, have found that sea shells can be used for desulfurization. To effectively use sea shells, they examined desulfurization characteristics of the shells of trough shells, surf clams, and scallops, and found that these shells were twice more effective in desulfurization than limestones being used now. Their key findings are that [the desulfurization rate] depends on the pore radius, and these shells have common crystal structures. These shells are expected to be used as an in-furnace desulfurization agent in fluidized bed combustion of powdered coal.

Concern on Pore Surface Area Hindered Exploration

Sulfur oxides produced by burning fossil fuels are causing problems because they produce acid rain. Sulfur in such fuels can be removed either before burning, by in-furnace desulfurization, or from the exhaust gas. This research project dealt with in-furnace desulfurization.

In the method [studied by the researchers], combustion and desulfurization are carried out simultaneously by fluidizing powdered coal, desulfurization agent, and air. This method is used in boiler combustion for thermal power generation and general industrial applications. Calcite-based limestone, a good desulfurization agent, is crushed, granulated, and sintered into a porous substance and used as a desulfurization agent. This type of boiler is operated at a temperature between 800°C and 850°C.

Desulfurization is accomplished by forming gypsum through chemical reactions among calcium in limestone, sulfur in fuel, and oxygen. The composition of sea shells is almost the same as that of limestone, and the present research was launched when the researchers wondered if sea shells could effectively be used as a desulfurization agent. Sea shells have been ignored so far because the surface area of the pores formed after sintering was smaller than that from limestone, and hence were assumed to lead to poor reaction rates.

Table 1. Pore radii

	Type of shell			Limestone
	Trough shells	Surf clams	Scallops	Tsukumi [limestone]
Average pore radius of raw material ($CaCO_3$) in micron	0.05	0.03	0.33	0.51
Average pore radius of CaO after sintering[a] in micron	0.86	1.12	0.95	0.44

[a] Sintering temperature 850°C; rate of rising temperature 50°/minute; sintering time 3 minutes; [sintered] in a nitrogen atmosphere

Table 2. Clams harvested in Japan (1992).

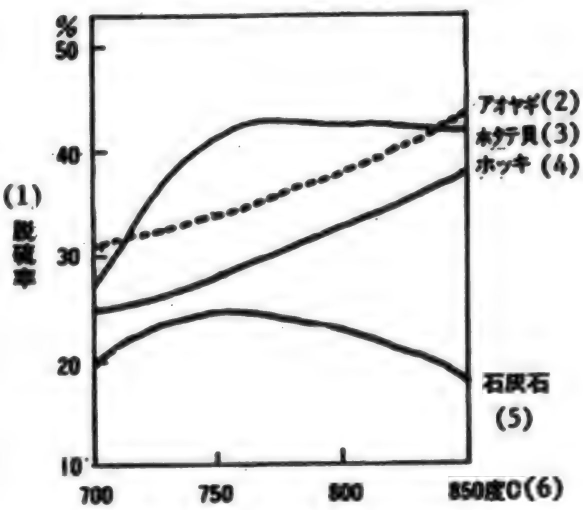
Scallop (shell and meat)	208,000 tons/year
Oysters (shell and meat)	245,000 tons/year
Shells collected from the cooling sea water channels of power stations	Hundreds of tons/year

Sulfur Is Distributed Uniformly Inside

The researchers compared [the desulfurization rates of] the shells of trough shells, surf shells and scallops, and limestone from Tsukumi under identical conditions. The specimen were crushed and sintered. The granule size of the specimen ranged between 297 and 420 microns. Sintered granules are porous, and the total surface area including the pores was 0.40 m^2 per gram for trough shells, 0.39 m^2 for surf shells, 0.59 m^2 for scallops, and 15.5 m^2 for limestone.

These specimen were tested for in-furnace desulfurization (between 700°C and 850°C). The test results indicated that desulfurization rates varied as the temperature rose, but the rates for shells always were higher [than the rate for limestone], reaching more than double [the limestone rate] at 850°C. [See Fig. 1.]

Fig. 1. Relation between desulfurization rate and desulfurization temperature.



Key: 1. Desulfurization rate 2. Trough shells 3. Scallops 4. Surf clams 5. Limestone 6. °C

The crystal structure of limestone and scallop is calcite while that of trough shell and surf clam is aragonite. The desulfurization rates of trough shells and surf clams rose monotonously as the temperature rose, while the rates of scallops and limestone decreased at temperatures above 750°C.

When the distribution of sulfur on granule cross sections after desulfurization was examined, the researchers found that sulfur was concentrated on the granule surface in the case of limestone, while sulfur was uniformly distributed throughout inside the granules made from sea shells. This difference is due to the difference in the pore radius. The average pore radius of sintered limestone granules is only 0.44 micron, and the pores are clogged when gypsum is formed, limiting the chemical reaction to take place only on the granule surface. In contrast, the pore radius of trough shell is 0.86 micron, that of surf clam is 1.12 microns, and that of scallop is 0.95 micron, thus allowing the chemical reaction to take place inside the granule as well. The key finding of this project is that the pore radius is more important than the pore surface area.

Abundant "Resource" of a Few Hundred Tons per Year

The amount of shells harvested in 1992 amounted to 208,000 tons of scallops and 245,000 tons of oysters. Clams collected from the cooling sea water channels of power stations amount to hundreds of tons per year. Some clam shells are used in art and crafts and in chicken feed, but most shells are thrown away.

Meanwhile, a large quantity of limestone is used as a desulfurization agent, and the gypsum produced by desulfurization reactions is used to pave roads. In a test conducted with a 50,000-kW power generating facility, which used air bubble fluidized bed coal combustion at normal pressures, a total of 130,000 tons of coal (sulfur content 0.5 percent) was burned in one year with 10,000 tons of limestone. If a substance with twice the desulfurization rate of limestone is used, only half as much is needed.

Shells are produced in the sea, unlike limestone that must be mined, and hence using shells not only helps to utilize garbage, but also helps the environment. This research deserves attention as a new technology in this respect. Assistant Naruse revealed that he had obtained similar results from experiments using short-necked clams and oysters.

AIST Establishes Committee to Review Japanese Industrial Standards to Promote Recycling

95FE0139B Tokyo NIHON KOGYO SHIMBUN in Japanese 19 Dec 94 p 2

[FBIS Translated Text] To strengthen the handling of environmental issues, the Agency of Industrial Science and Technology [AIST] of the Ministry of International Trade and Industry [MITI] has begun a full-scale study on a wide-ranging response to recycling based on the Japanese Industrial Standards [JIS]. As an internal organization, AIST has recently established the Committee to Review JIS for Accelerated Recycling, in which all divisions (six divisions and two offices) of the Standards Department participate. This committee will review all of the over 8,000 items in JIS with the following emphasis: In product specifications, raw materials that improve recycling percentage will be specified, and in labeling specifications, symbols will be added for efficient collection of sorted items. This study also responds to the long-term planning of industrial standardization which will begin in April 1996.

This review committee in principle meets once a week. The committee consists of approximately 13 members, including the managing group leader from each division and specialists on industrial standards, and is chaired by Tetsuo Okabayashi, chief of the Textile and Chemical Standards Division. As for revising JIS for recycling, approximately 40 specifications have already been adopted, including those on slag aggregates, toilet paper, and recycled steel. Some construction materials, such as rolled steel for general structure made from iron scraps, have been adopted as purchase standards for public construction projects.

This new committee was established based on the judgment that it was necessary to tackle recycling issues across the board and not limited to specific products or labels as the social awareness on environmental issues had been increasing. The committee is expected to discuss the expansion of items [in JIS] related to the usage of recycled resources and recyclable raw materials as well as the standard labeling for sorting.

The Japan Industrial Standards Survey Council, which advises relevant ministers, such as the Minister of International Trade and Industry, has recently established the Special Committee to Review Long-Term Plan for Industrial Standardization (chaired by Yotaro Handa). The Special Committee will discuss and review the Eighth Long-Term Plan for Industrial Standards, which will begin in April 1996. In January 1995, a working committee will be established to study recycling issues and JIS marks in response to social needs. The new committee established in AIST will work together with this working committee of the Survey Council and accelerate recycling through JIS.

Yokohama National University Develops Technology to Decompose Trichloroethylene Using Photocatalyst

95FE0139C Tokyo NIKKEI SANGYO SHIMBUN in Japanese 2 Nov 94 p 5

[FBIS Translated Text] A group led by Professor Masayuki Murabayashi of the Institute of Environmental Science and Technology, Yokohama National University, has developed a technology to decompose quickly organochlorine compounds, such as trichloroethylene, a

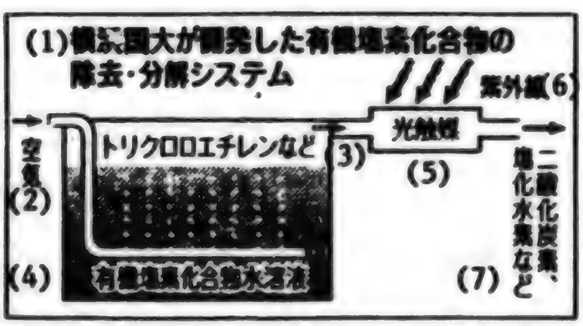
suspected carcinogen. Glass fibers are coated with titanium oxide as a photocatalyst, and air that contains organochlorine compounds is passed through the fibers while being irradiated with ultraviolet light. This technology is expected to be useful in purifying waste water or soil polluted by organochlorine compounds. This new result was reported at a photocatalyst symposium held at Tokyo University in Hongo, Tokyo, on 1 November.

The newly developed system consists of two steps: (1) organochlorine compounds are gasified by passing air bubbles through an aqueous solution of the compounds; and (2) the gasified compounds are decomposed into carbon dioxide and hydrogen chloride. Carbon dioxide is harmless, while hydrogen chloride dissolves in water and forms hydrochloric acid, but the acid can be neutralized and rendered harmless.

Titanium oxide was used in the second step. When titanium oxide absorbs ultraviolet light, it accelerates chemical reactions by using the light energy, thus acting as a photocatalyst. This compound is attracting attention especially as one of the few catalysts that can sever the bond between a carbon atom and a chlorine atom in organochlorine compounds.

Other systems have been proposed to decompose organochlorine compounds by suspending titanium oxide photocatalyst particles in an aqueous solution of the compounds, but such systems have practical difficulties, such as taking several hours due to slow reaction rates. This new system can decompose in about 30 minutes because it uses reactions in gas phase, in which molecular motion is rapid.

A series of related technologies that constitute the new system has already been established. Professor Murabayashi expects that "[the new system] can be applied to purify polluted underground water or to process waste water discharged by semiconductor factories, if we reduce cost by using the sunlight as a light source."



Key: 1. System developed by Yokohama National University to decompose and remove organochlorine compounds 2. Air 3. Trichloroethylene, etc. 4. Aqueous solution of organochlorine compounds 5. Photocatalyst 6. Ultraviolet light 7. Carbon dioxide, hydrogen chloride, etc.

Organochlorine compounds such as trichloroethylene are used in cleaning semiconductors and precision machinery, and the resulting waste water pollutes soil and underground water. Prior to 1989, there were no legal standards on residuals [organochlorine compounds] in underground water, and the pollutants have become a "high-technology pollution" issue. These compounds are not decomposed by microbes, and the processing of the compounds in soil still remains a problem.

Comment

Comment by Professor Akira Fujishima of the Faculty of Engineering, Tokyo University: Photocatalysts are suitable for decomposing pollutants that are spread thin. The catalysts are used in tiles that remove bad odor or to decompose spilled crude oil. This new system will eventually find powerful applications in decomposing organochlorine compounds.

STA To Begin Project to Develop Undersea Observation System With Industry, Academia

95FE0139D Tokyo KAGAKU KOGYO NIPPO in Japanese 16 Nov 94 p 1

[FBIS Translated Text] The Science and Technology Agency [STA] has decided to start a project to develop a "Multi-Purpose Network to Monitor Global Environment Using the Seabed Cable System" in the fiscal year 1995. This will be a joint project among industry, academia and the government. This network is a long-term seabed observation system to continuously monitor various environmental changes that take place on the ocean floor. This multi-purpose observation on the ocean floor will be conducted by utilizing coaxial cables given up by Kokusai Denshin Denwa Company [KDD]. At present, a feasibility study of this project is underway using the funds from the 1994 science and technology promotion fund. The result of the feasibility study will be reported to a feasibility study subcommittee under the Policy Committee of the Science and Technology Council. After the subcommittee approves the project, it will be launched around April 1995.

As part of a generation change, seabed coaxial cables are being replaced rapidly by optical fiber cables, which enable large volume communications. The feasibility study has focused its attention on coaxial cables idled as a result of the transition to optical fibers. The feasibility study group is reviewing connection technology to use the coaxial cables as a seabed observation system, the development of various sensors to install on the cables, and the identification of R&D topics to build the observation system.

The coaxial cables to be used in the observation system belongs to TPC-2, which will be transferred from KDD. The cables are laid between Okinawa and Guam. Using the observation system based on these cables, the project will first study the sinking of the oceanic plate in the

Ryukyu Trench, which is strongly coupled to earthquakes and tsunamis. Additional observation bases will be established on Okinotori-shima [Douglas Reef] and Mariana Trough to observe earthquakes and conduct ecological studies around the hot-water [seabed] fountains.

Emphasis will also be given to basic and measurement technologies to build the observation network. One of the development topics is "non-contact coupling," an advanced coupling technology. With this technology, a coaxial cable and a signal cable can be coupled without physical contact between the cables. Such a technology will make it unnecessary to raise the cable to the surface because the connection work can be carried out on seabed. In parallel, sturdy measurement devices that can withstand the pressure that accompanies deep undersea observation will be developed.

Tohoku Electric Power Co., Japanese Universities Jointly Develop Technology to Decompose Freon Using Hydrothermal Reaction

95FE0139E Tokyo NIKKEI SANGYO SHIMBUN in Japanese 1 Dec 94 p 13

[FBIS Translated Text] Sendai—Jointly with Tohoku University and Kochi University, Tohoku Electric Power Company has developed a decomposition device for the specified freon, which is considered to be responsible for the destruction of the ozone layer. The specified freon is continuously decomposed by adding an aqueous solution of sodium hydroxide to liquid freon to start hydrothermal reactions at high temperature and pressure. The Conference of the Signatories of the Countries have agreed at the Fourth Meeting of the Parties to the Montreal Protocol to ban the specified freon completely by the end of 1995, but it is difficult to decompose the freon because it is chemically stable. At present, many research laboratories are trying to develop technologies to decompose the specified freon. This new device has a relatively simple structure, and hence "it is possible to make the device small and inexpensive." The developers plan to work further and aim at early commercialization.

In addition to Tohoku Electric Power, the joint developers are Professor Heiji Enomoto of the Faculty of Engineering, Tohoku University, Professor Nakamichi Yamazaki of the Faculty of Science, Kochi University, and Oei Development Industry (president Toyomori Morisawa; located in Kochi), a dredging contractor.

[In the new device,] liquid freon is mixed with an aqueous solution, in which sodium hydroxide and methanol is mixed in equal proportion. The liquid mixture is then pumped into a reaction vessel under a pressure of 200 kilograms per square centimeter generated by a high-pressure pump. When heated to 240°C, the liquid is decomposed into fluorine ions and chlorine ions in about two minutes. The ions combine with sodium ions, become harmless sodium chloride and sodium fluoride, and then recovered.

In their experiment, 99.99 percent of freon was decomposed when the liquid was heated to 240°C, and this high rate of decomposition remained constant even after some time. This new device can decompose 10 kilograms of liquid freon in one hour. The R&D cost was approximately ¥ 50 million.

In their experiment, they confirmed the decomposition of liquid freon only. In the future, the group will experiment on the decomposition of freon gas, which is widely used as a refrigerant. This method will also be applied to the continuous decomposition of trichloroethylene, which is an organochlorine compound difficult to decompose, and high-polymer wastes such as polyethylene.

FY94 Nuclear Power Safety White Paper Outline

95FE0155A Tokyo NIKKAN KOGYO SHIMBUN in Japanese 21 Jan 95 p 7

[FBIS Translated Text] The foremost characteristic of the 1994 edition of "Nuclear Power Safety White Paper" is that, based on the theme of "international trends in nuclear safety," it examines the way in which "safety culture" is developing throughout the world. According to the white paper, drawing a lesson from the former Soviet Union's Chernobyl disaster, which greatly affected the safety of other countries as well, worldwide efforts to build an international safety regulation system are making progress. The white paper analyzes the situation from the standpoint of safety culture. Its first chapter deals with the concept of "safety culture," while the second chapter alludes to international activities to create the "safety culture."

Multiple Protection Measure

In the event of a nuclear disaster, one should bear in mind that nuclear power knows no "national borders" since damage will spread to neighboring countries as well. The world is keeping a close watch on the nuclear safety measures being formulated by the former Soviet Union and Eastern European countries as well as various Asian countries which are pursuing nuclear power development with keen interest. Since the Chernobyl disaster, international activities aimed at improving nuclear safety are gathering momentum throughout the world.

This is one of the reasons why the former Soviet Union and Eastern European and Asian countries chose to become participants in the worldwide nuclear power safety pact, "Convention Concerning Nuclear Power Safety," which was adopted in June 1994. Since the treaty does not take effect until it is ratified by 22 countries, each of fifty-three countries which adopted the treaty is proceeding with the necessary preparation.

"Safety culture" is a concept underlying safety. It means that organizations and individuals who will be involved in future nuclear power development will be courageous enough to make safety their top priority no matter what. The industrialized countries such as Japan, the United States, and Western European countries have adopted this approach since the beginning and accordingly incorporated safety measures based on multiple protection approach, lessons learned from the past nuclear disasters and breakdowns, and knowledge gained from actual operating experiences.

Analysis of Accident Data

More specifically, safety measures are being developed centering around the International Atomic Energy Agency (IAEA) which began its activities in 1957, OECD/NEA, OECD/IEA, and [International Committee for Radiation Protection] (ICRP).

IAEA sends a nuclear operation management survey team (OSART) and important safety event analysis team (ASSET) to each country in order to make certain that the country involved is adhering to the international safety standards when operating nuclear reactors and performing safety evaluation. Moreover, in March 1985, IAEA established the International Nuclear Safety Advisory Group (INSAG) to advise on important safety matters. OECD/NEA performs analysis and assessment of accidents and failures using its failure report system (IRS).

It took the U.S.'s Three-Mile Island nuclear accident of 1973 and the Chernobyl disaster in April 1986 before the safety culture took roots. Stressing the seriousness of these two incidents, IAEA conducted on-site investigation and put together deliberations in a document designated as INSAG-1. In this document, IAEA used the term, "safety culture," for the first time to describe an approach which places safety as an absolute top priority. Subsequently, in March 1988, IAEA came up with the concept of safety culture as an essential element in nuclear power development, firmly establishing it in the fundamental thinking of nuclear safety, "[The principle of basic safety at power plants] (INSAG-3)."

53 Countries To Participate

Following INSAG-3, as existing conditions of the nuclear power plants in the former Soviet Union and Eastern European countries became better known, INSAG further incorporated the concept of "safety culture" into the construction and operation of nuclear power plants in a more concrete form and established the present version of "INSAG-4" in 1991.

Thus the concept of safety culture, which until then had remained merely a vague concept, took on a more concrete form. Safety culture is a top priority not only with on-site workers such as nuclear reactor operators but with governmental and other responsible bodies as well; in other words, the total process of nuclear power development is governed by this concept.

In June 1994, the IAEA-sponsored Nuclear Safety International Conference adopted the "Nuclear Safety Treaty," urging participants to make every effort to achieve and maintain a measure of nuclear safety. At present, 53 countries expressed their intention to participate, all of whom are now working in the ratification of this treaty.

It is common knowledge among those in Japan and other advanced countries that safety should be the foremost concern in nuclear power development and therefore must be treated as the top priority. In order to firmly establish this concept of safety among those in the former Soviet Union, Eastern European countries, and various Asian countries, where the safety system at best is inadequate, it is necessary to spread the ethos of "safety culture" to every corner of the world.

Necessary To Raise Level Further

Commentary

Those involved in nuclear energy development must have the courage to make safety a top priority at any

cost. Because of the country's scarce resources, Japan has to turn to nuclear power for one-third of its energy need. Any nuclear disaster caused by man will result in halting of nuclear reactor operations, which will shake Japan's economic foundation and ultimately destroy livelihood and living conditions of every individual. For this reason, Japan's "safety at any cost" ethos is completely reflected in its handling of nuclear power development, from the initial stage through nuclear reactor design stage. That is why Japan ranks top in the world insofar as nuclear safety reliability is concerned. The white paper introduces the rising trend of "safety at any cost" ethos throughout the world, describing the way in which international organizations are dealing with this problem.

Emphasizing Japan's role as a leader in the field of nuclear safety, Mr. Toko Yasumas, chairman of the Nuclear Safety Commission, said, "The nuclear safety measure on which Japan had worked from the very beginning epitomizes its thinking of giving top priority to safety at any cost. We assisted in the drafting of INSAG and the Nuclear Safety Treaty."

The fact that the Japanese took up the international nuclear issue for the first time in its government's white paper is an indication of its high confidence level. Needless to say, if Japan is going to deal with the problem of nuclear safety on a worldwide scale, it must raise its performance level.

In order to solve the future energy problems of Asia, including China, it is essential that Japan take the problems accompanying nuclear energy development head on. Since nuclear safety problems know no national boundaries, they will boomerang on us directly or indirectly. In order for Japan to continue its world leadership in the nuclear safety field, we should aim for a higher safety level while at the same time providing the world with our knowledge and technology acquired over the years.

Priority Research Subjects at Toshiba's Nuclear Engineering Lab

95FE0155B Tokyo NIKKEI SANGYO SHIMBUN in Japanese 20 Dec 94 p 9

[FBIS Translated Text] Development of the next generation of a nuclear power generation system is moving forward at a rapid pace. A focal point of the development work carried out jointly by an electric power company and an electricity manufacturer is to improve both safety and operational efficiency. In the midst of all this, at the nuclear engineering laboratory providing a nuclear base for the Toshiba Group, with robotic inspection process as a central theme, approximately 400 researchers are tackling this problem by repeating the same approach from various angles to achieve the objective.

Basic Research Group

The main research themes stressed by the Nuclear Engineering Laboratory consist of three, viz., development of next-generation type nuclear reactor, improved efficiency of maintenance and conservation systems, and establishment of nuclear fuel cycles. The research groups are divided into the following seven basic research fields: (1) nuclear reactor and its peripheral fields; (2) pump, valve, and other mechanical parts; (3) electric control technology; (4) chemistry; (5) analysis of phenomena and simulations; (6) materials used in plant tools and equipment; and (7) radiation measurement. The laboratory adopted a method of operation which involves formation of a project team for each developmental objective cutting across each research group.

Laboratory Director Takio Miyazawa said, "The present nuclear power technology is nearing completion insofar as the part involving hardware, such as power generation capability, is concerned." What the Toshiba Group currently bears in mind while proceeding with the developmental work is, "Ease of use and improved maintainability."

As a method of improving maintenance systems, researchers are utilizing robots more effectively. In parallel to their efforts in developing the equipment itself which does not require as frequent routine inspections as before, they are trying to come up with a more efficient method of inspection by using robots.

Use of "Dynamic Vibration Absorber"

For instance, at present, robots used in inspecting a surrounding area of a nuclear reactor mainly are a monorail-type designed to move on rails. However, if a robot can be designed to move freely within a plant and to manipulate welding operation with a remote control, then maintenance efficiency can be improved substantially. Their present research activities are focused on the question of "how to make a robot move forward without colliding with an obstacle standing in its way."

In dealing with the foremost theme of safety related to nuclear power generation, researchers worked out a new concept which makes use of a natural force. An example of this is the application of dynamic vibration absorber technology, currently used in high-rise buildings, to aseismic equipment designed to prevent effects of shaking on a plant when an earthquake strikes.

When an earthquake strikes, a pendulum attached to the equipment shakes and automatically absorbs vibration of the main body of the equipment. Until now, a method of securing the equipment to floors or walls using a support generally has been used. The use of the dynamic vibration absorber, however, not only enhances safety but also substantially reduces facility costs. Practical utilization technology for this has already been established, and electric power companies are being urged to use this device.

Nuclear Engineering Laboratory's Responsibility Becoming Weightier

The laboratory is aiming for the development of a similar technology for an emergency core-cooling system

(ECCS) designed to be activated when trouble occurs in a reactor core. Currently used method on the whole sends cooling water with a pump; however, the researchers are looking into a method which changes vapor into water by cooling it and use this water for cooling reactor core. With this method, it is not necessary to pump water. The nuclear engineering laboratory plans to use such a passive safety system in the future in a wide variety of fields.

Although the next generation of nuclear reactor may not reach a practical stage until the year 2010, safety is a problem which must be dealt with on a top priority basis. Since the anti-nuclear movements here and abroad are deeply rooted, "it will be necessary to proceed with utmost caution." (Director Miyazawa)

Take a developmental direction as an example. It is full of delicate elements to be considered and dealt with. A responsibility which goes with the role played by the laboratory will increasingly become heavier as Toshiba's nuclear power development plan expands.

Toshiba Nuclear Engineering Laboratory

Established: October 1978 Address: 4-1, Ukijimacho, Kawasaki Ward, Kawasaki City, Kanagawa Prefecture Number of Researchers: approximately 400 Contents of Research Undertaking: R&D of technology related to use of nuclear power.

IHI To Improve Nuclear Energy Efficiency Using Optical Discs

95FE0155C Tokyo NIKKEI SANGYO SHIMBUN in Japanese 7 Dec 94 p 12

[FBIS Translated Text] Ishikawajima-Harima Heavy Industries (IHI) plans to increase design efficiency of its Nuclear Power Plant Division by 30 percent by the end of 1995. At the company's Yokohama Engineering Center serving as a design base for nuclear power and industrial machines operating since April 1994, a centralized system is implemented to store and manage design drawings by using optical disks. Thus the company is pursuing a paperless system to increase efficiency. In the area of heavy machineries, Mitsubishi Heavy Industries has come out with a plan to reduce design cost by 10 percent, which is another indication of progress made in cost cutting in the very beginning of design.

Efforts to achieve a paperless environment also are evidenced at the New Engineering Center, which implemented "integrated drawing management and retrieval system." At the center, each engineer is provided with a workstation terminal linked to the system, storing design drawings in optical files. These files can be accessed also from terminals at construction sites. Some sections have implemented a tele-conferencing system capability.

Design efficiency has been raised by 30 percent throughout, beginning with basic design through production design. At present, IHI has achieved 70 percent of the initial cost reduction goal, and by the end of 1995, hopes to cut back design cost by 30 percent not only in the Nuclear Power Plant Division but also in the Industrial Machinery Plant Headquarters.

In the general heavy machinery industry, in addition to Mitsubishi Heavy Industries aiming for a 10 percent reduction in design costs (annual cost ¥180 billion), Hitachi Zosen Corporation is attempting to cut in half the design cost of its shipbuilding division over a period of two years, 1994-1995. Thus the industry's cost-cutting efforts are now extending beyond plants and indirect divisions to design divisions.

PNC To Build Multiple Barrier System for Underground High Level Waste Disposal

95FE0155D Tokyo KAGAKU KOGYO NIPPO in Japanese 29 Nov 94 p 12

[FBIS Translated Text] As a safety protection system designed to ensure long-term safety of high-level radioactive wastes which are disposed underground, construction of a "multiple barrier system" is being considered. At its "second meeting to report on the underground disposal R&D" held on November 28 at Sankei Hall's Sankei Club House, the Power Reactor and Nuclear Fuel Development Corporation (PNC) revealed the result of performance evaluation research aimed at validating the effectiveness of the multiple barrier system from a technical standpoint and important problems currently facing them.

Concerning a measure for dealing with highly radioactive wastes separated from spent fuel produced in the course of nuclear power generation, the Atomic Energy Commission's basic policy is to dispose of them deep in the ground, approximately a few hundred meters below ground, after they have been solidified in a stable state. The multiple barrier system plays an important role as it prevents highly radioactive waste disposal from contaminating human environment by isolating it. The system combines a safety barrier consisting of several layers of "man-made barrier" and a "natural barrier" of earth layers naturally equipped with safety protection function.

As for performance evaluation research, PNC listed the following as conditions which must be satisfied by the system: (1) contact with underground water suppressed, (2) elution and movement of nuclide suppressed, and (3) environmental safety verified. Each of these requirements is being studied. In its study of bentonite, a leading candidate for one of the cushioning materials used in the man-made barrier, PNC revealed that "by keeping the temperature of bentonite below 100°C, we can maintain its mineral stability for a long period of time." Concerning one of the "overpack" materials used in the man-made barriers, carbon steel is considered the most promising. According to PNC, prospects for producing from this material the "overpack" capable of maintaining its corrosive resistance characteristic for over a year are good. It also has become evident that the

near field, made of rock mass in the vicinity of the artificial barrier, is most likely to possess the ability to suppress the movement of radioactive nuclide.

The aim of the performance evaluation research is to construct a mathematical model to account for various phenomena of the multiple barrier system against underground water. This model and experiment data will be used to ascertain system reliability. The immediate goal is build a near-field model. In accordance with its policy, PNC plans to pursue research concerning a geosphere model, including the far-field ([wide land] strata outside the near field), and a biosphere model. Based on those results, PNC hopes to put together the second R&D report on underground disposal technology prior to the year 2000.

PNC's Vitrification Technology for Radioactive Waste

95FE0155E Tokyo NIKKAN KOGYO SHIMBUN in Japanese 28 Nov 94 p 7

[FBIS Translated Text] Disposal of radioactive waste is a problem which no nuclear power plant can evade. Although "one through," which can separate wastes from human environment without using human operators to process spent fuel, is the simplest disposal method it is not suited for energy-resource-poor and land-scarce Japan. It has, therefore, selected a method allowing Japan to reuse waste repeatedly. For this reason, Japan has a troublesome problem of disposing highly radioactive waste produced in the course of recovering residual uranium and plutonium. To solve this problem, the Science and Technology Agency's Power Reactor and Nuclear Fuel Corporation has undertaken the development of a practical "vitrification" technology, designed to harden waste by mixing it with glass and dispose it underground. Moreover, around April of 1995, [Nihon Gennen] will begin storing vitrified waste temporarily at its nuclear fuel cycle facilities located in Rokkasho Village in Aomori Prefecture. Well, then what kind of technology is this vitrification?

The vitrification technology goes back to the latter part of the 1950s when the United States, Canada, France, England, and the former West Germany began its research. In Japan, PNC started its development almost 20 years ago.

Glass has a physically stable property which cannot be affected by radiation. The vitrification technology made the most of this characteristic.

Reprocessing of spent fuel begins with cutting each aggregate of fuel. The aggregate is fused at high temperature in a fusion tank using nitrate to extract unburned residual uranium and plutonium. The waste liquid produced at that time containing various types of radioactive materials is a highly radioactive waste.

Glass material used in vitrification is borosilicate glass. Since glass has a network structure, radioactive substance enters into the network, making it a well-balanced stable material. It does not mix with glass but rather, like a colored glass, integrate into it as a component. For this reason, even if it cracks, glass and radioactive material will never be separated.

With the PNC method, the waste liquid is thickened first by reducing its volume to one half and then melted in a fusion furnace. It is then forced into a glass-fiber cartridge made of borosilicate glass to facilitate its handling.

The vitrification process can be handled by using one of two methods: the AVM method designed to pour waste liquid into a stainless container after it has been melted in a fusion furnace and the LFCM method designed to heat glass itself with electric current by using a ceramic fusion furnace. PNC employs the latter.

The stainless container (canister) is a cylindrical structure measuring 43 cm in outer diameter and 104 cm in height, and weighs 380 kg. Its radioactive quantity is 400,000 Ci and its calorific volume 1.4kW, slightly stronger than that of an electric stove.

On the other hand, vitrified waste temporarily stored by Nihon Gennen was prepared by France's [Cojema] Co. at the request of Nihon Gennen for reprocessing. It measures 43 cm in outer diameter and 134 cm in height. It weighs 490 kg.

After it has been cooled by air while in storage in the high-level radioactive waste storage building for a period of 30 to 50 years, it will be transported to the final processing site and buried underground. Since the storage building is constructed with strong reinforced concrete and canisters are placed in a carbon steel receptor, it will not be destroyed by earthquake.

The Science and Technology Agency is stressing the rationality and safety of nuclear energy by stating that if one half of the electricity used by a Japanese in his lifetime is to be supplied by nuclear power, the vitrified high-level radioactive waste produced in this case amounts to no more than a size of two golf balls put together.

STA Conducts Research on Structure of New Superconductors

94FE0930A Tokyo NIKKEI SANGYO SHIMBUN in Japanese 1 Sep 94 p 5

[FBIS Translated Text] The structure and composition of a new metallic superconductor which has a high critical temperature (the temperature at which it becomes a superconducting material) has been determined. The new superconductor was discovered by a joint Japan-U.S. research group in the Metal Materials Laboratory of Japan's Science and Technology Agency. The crystal structure, which is tetragonal, is presumed to be a type of intermetallic compound, consisting of yttrium, palladium, boron, and carbon bonded at a ratio of 1:2:2:1.5. Although the development of superconducting materials has focused on oxide systems, which have a higher critical temperature than metals, it is now possible that metallic materials could again draw attention as being suitable for wire and device applications, depending on the outcome of research on the new material.

The new superconductor belongs to a new material group called boronic carbides, and it has a critical temperature of 23° Kelvin (250° below O° C), which is on the same level as niobium 3 germanium, which has held the highest record to date. Although it was announced at the beginning of 1994 that a joint group consisting of AT&T (U.S.) and the Tokyo University Dept. of Engineering had succeeded in synthesizing the material, the synthetic samples consisted of a mixture of physical structures, and it was not known which one of them exhibited the superconducting property. At the Metals Technology laboratory, samples with slightly different compositions were created by arc welded in argon gas, and X-ray diffraction was used to determine what type of physical structures were prevalent in each sample. Next, a superconducting quantum interference device (SQUID) was used to determine which samples contained the most physical structures which exhibit superconducting properties. The physical structure was identified by compiling and examining this type of data.

U.S.-Japan joint development groups, such as this one involving AT&T, have also synthesized a metal compound superconductor which has a critical temperature of 16.6° Kelvin, by adding nickel instead of palladium. The physical structure of this material has also been identified. The structure of the new superconductor identified by the Metal Materials Laboratory is basically the same as the superconductor which contains nickel. However, the carbide content is different, and a more detailed analysis will be performed in the future.

The superconductor made of the new intermetallic compound can achieve critical temperature when used in bulk, whereas niobium 3 germanium, which has the same critical temperature, can only achieve high temperature applications when used as thin film. Researchers are hopeful that the critical temperature can be improved a step further by developing more advanced materials based on these new results.

MAGLEV Train Requires No Magnets

KAST Tests Model Successfully

95P60088A Tokyo NIHON KEIZAI SHIMBUN in Japanese 7 Jan 95 p 12

[FBIS Translated Text] A train that moves without touching the rails. The research group of Kanagawa Academy of Science and Technology (KAST), led by Professor Toshio Higuchi of Tokyo University, has developed a new theory of magnetic levitation technology and successfully carried out a levitating experiment with a model train. The new technology combines the characteristics of high temperature superconducting materials with tough and cheap iron for the rails. Conventional technology which employs magnetic repulsion and attraction requires magnets in both the train and the rails. Since the new technology requires only iron rails, "considerable cost reduction can be expected," said Prof. Higuchi.

The prototype model measures a total of 24 centimeters in length and weighs 1.4 kilograms. The propulsion mechanism is not installed in the train, but placed underneath the iron rails. The rails are a total of 1.8 meters in length and slightly slanted. The train moves smoothly just 0.5 millimeters beneath the rails.

The secret is the line of magnetic force which connects the high temperature superconductor embedded in the model and the iron rails. Ordinary magnets would not move once they are placed on the iron rails. But the magnetic line of force from the high temperature superconductor works like an "invisible spring" and the superconductor levitates in the space just beneath the iron rails.

This phenomenon was discovered by Higuchi and his research group last year. According to Higuchi, this phenomenon can be applied to levitating transport systems in clean rooms and flywheels for energy storage for kinetic energy after conversion from electricity.

NEC Starts Multimedia Information System Integration Operation

94FE0892A Tokyo NIKKAN KOGYO SHIMBUN in Japanese 8 Aug 94 p 9

[FBIS Translated Text] NEC started a multimedia information system integration operation. The company uses a system that combines a PC98 personal computer with NEC's own independently developed multimedia software development tool to handle the many tasks of custom-ordered system development—from planning and design to data collection and [software] production. Recently NEC delivered a public facilities information system to the operation's first customer, the Citizen's Information Center of Hekinan City in Aichi Prefecture. NEC hopes to use this as an opportunity to make inroads in the area of information content as well as conventional multimedia technology fields such as communications, hardware, and software.

NEC's system integration is the foundation for the tool it developed that is called "Hyper Platform." Hyper Platform is an authoring tool for developing multimedia software without any programming. Sound, animation, and other forms of data, and the environment for manipulating the data are prepared in advance in the form of objects. The user can incorporate those objects into a system by simply giving directions to the Hyper Platform system. The use of the tool can shorten multimedia software development time to one-third the time it usually takes.

NEC named the system that combines its PC98 personal computer with the Hyper Platform tool the "98 Data Hall" and offers multimedia system integration based on it. The system does not require special hardware for video processing, such as a video processor or A/D converter, and can build multimedia information systems for one-half to one-third the normal cost.

Users of the public facilities information system developed for NEC's first customer in this venture, Hekinan City, touch images of major facilities within the city that are displayed on the system's screen to get summaries and maps in the form of photographs, guides, and audio summaries. After this NEC will target local municipalities, the education market, and the distribution services market and plans to develop 300 such systems within three years. With that NEC will expand its operation into a total service that covers everything from multimedia information system planning and building to maintenance.

Hong Kong To Adopt Japanese Personal Handy Phone System

94FE0892B Tokyo NIHON KEIZAI SHIMBUN in Japanese 7 Aug 94 p 1

[FBIS Translated Text] Hong Kong's Telecommunications Management Agency decided on a plan to introduce a Japanese-style personal handy phone (PHS) system and has asked Japan's Ministry of Post and Telecommunications (MPT) to cooperate in the effort. Hong Kong's Telecommunications Management Agency will try to make PHS practical in Hong Kong by next summer and wants to use the same frequency band that is used in Japan. On the Japanese side, the MPT and private firms had jointly appealed to Hong Kong to adopt the Japanese PHS system. If it is realized, people who use a PHS in Japan will also be able to use it in Hong Kong when they travel there. The MPT intends to actively cooperate because the equipment sales market would expand for manufacturers, and the sales price of terminals can be expected to come down in Japan.

The PHS is the new generation of portable telephones that was independently developed in Japan. It lies in the middle between the cordless phones used in homes and portable car phones, and has already been successful in practical-use tests in Japan. Within the fiscal year business licenses will be issued, and by as early as next summer or fall the PHS system will be ready for practical use. There is another advantage to the PHS in that the basic charge will be about ¥3,000, which is one-third as much as in the standard case of a car phone. An MPT research group estimated that in 2010 there will be 38 million PHSs in use, which is about 19 times the number of portable phones now in use.

According to the request made to the MPT, Hong Kong judged that, of the new portable phone systems about to be introduced in advanced countries, Europe's DECT system and the U.S.'s CDMA system are not yet in the practical-use stage, so Hong Kong decided to introduce Japan's PHS system. There also is the aspect that introducing a PHS system in the small area that makes up Hong Kong would be easy because setting up the base stations would be easy. The frequency band of the radio waves that Hong Kong will use is the same 1895- to 1918.1-megahertz band that Japan allocated for domestic use this June. That bandwidth would immediately allow for about 6 million subscribers in Hong Kong.

Hong Kong says that it will accept applications from those wanting to get into the PHS business from this October to December and that official licenses will be granted from next January to March. This schedule is about the same as that which the MPT anticipates in Japan. Although it also depends on how many want to get licenses in Hong Kong and whether base stations will be set up, a practical-use PHS system looks possible by sometime between next summer and next fall.

The advice that Hong Kong sought from the MPT has to do with technical issues such as how to connect exchanges and set transmission speeds. As the area over which a communications system is used expands, the cost of the terminal equipment and the cost of facilities such as exchanges and base stations strongly tends to decrease.

Not only will both Japanese and Hong Kong users be able to buy terminals for a lower price, the terminals that they buy can also be used in both countries. Because that will make the PHS systems more convenient, the MPT "will actively cooperate."

The group that has worked with the MPT in persuading Hong Kong to use the Japanese style of new-generation portable phones is a voluntary group called the "Asia Pacific Mobile Communications Liaison Council" and is made up of 28 private companies that include NTT, KDD, and NEC. Firms that compete with each other for business are members of the liaison council, and even U.S. and European firms that have incorporated in Japan, such as Motorola of the U.S. and Erikson of Sweden, are members.

For that reason the MPT does not have to worry about Hong Kong's use of a Japanese-style system causing any discord with Europe or the U.S. The MPT and the liaison council also plan to get other countries to use the PHS system.

NEC Develops Multimedia Information Collection System

94FE0892C Tokyo DEMPA SHIMBUN in Japanese 5 Aug 94 p 5

[FBIS Translated Text] On 4 August NEC announced the development of a multimedia information collection system called "Live on Demand" that can efficiently collect multimedia information from multiple points for a low cost.

The system connects through a looped fiber-optic cable to multiple cameras and other such multimedia input terminals to efficiently gather multimedia information. Applications of the system are expected in areas that require the collection and utilization of multimedia information such as local information (events, weather information, roadway information) and sports scenes (individual players, local matches), and various kinds of monitored information.

Live on Demand was realized as a result of (1) the use of "subcarrier multiplexed multi-access optical transmission technology," which made possible the simultaneous gathering of multimedia information with a single optical fiber because the multimedia information is multiplexed and then transmitted optically, and (2) the development of "subcarrier relay point multiplexing," which suppresses the generation of beat noise, occuring when multiple signals interfere with each other, and thereby enables larger-scale and lower-cost systems.

With those technologies NEC realized a highly practical system that can efficiently transmit multimedia information, can be enlarged in scale, and can be made for a lower cost.

Applications as an information collection system include use of the system to gather information about local events, regional weather, traffic conditions, and street corners, and to relay sports. As a multimedia service, the Furthermore, some nearer applications are in various types of infrastructure monitoring, such as remote monitoring of dams, power plants, transmission lines, roadways, crossings, and tunnels; safety monitoring for stations, airports, ports, factories, stages, stores, and financial organizations; and monitoring and providing guides to parking lots, parks, and so forth.

NEC plans to continue its R&D efforts aimed at making the system practical in the near future and turning it into a product.

MPT Installs Wireless LAN, First in Government

94FE0892D Tokyo NIKKEI SANGYO SHIMBUN in Japanese 5 Aug 94 p 7

[FBIS Translated Text] On 6 April the Ministry of Posts and Telecommunications (MPT) put into operation the largest-scale wireless LAN (local area network) in all of the government's agencies and ministries. This is the first actual introduction of a LAN in a government organization. Although a supplementary budget for economic measures was applied in this case, the move looks like it will give further impetus to the Japanese government's use of computerized information systems, which lags far behind that in the U.S. and Europe.

Electronic Mail To Be Routine

27 July—An electronic mail message is sent to the personal computer in the office of Councilor Shinagawa of the Minister's Secretariat. It is a message from a section chief under him. "I met with the university professor whom you requested." Councilor Shinagawa, who had just reported to his office, confirmed the content of the message then closed it and went on to his other work. Opening electronic mail messages every morning is becoming routine, and the regular work of correspondence is becoming efficient, too.

Initially, the MPT's wireless LAN linked about 800 personal computers. That worked out to be one computer per person for section chiefs and higher-level personnel, and three to four other workers sharing one personal computer. During FY1995 the MPT plans to increase the number of computers to 2,600 so that every worker will have their own personal computer. The total cost stands at ¥4.5 billion.

From the outset the view was that "something is strange when the use of information systems by the ministry in charge of information communications lags behind that of private firms." The plan itself began in 1991. However, the chance for the MPT to get a budget for the LAN came with the first FY93 supplementary budget for economic measures. With that, the concept suddenly took on a concrete form.

The LAN is a client-server system that can flexibly cope with the individual needs of the ministry's departments. There are no large mainframe computers on the LAN.

acting as document management servers that handle the electronic bulletin board and other functions. There are also 10 UNIX workstations that manage documents for all departments and function as devices for outside connections.

Ethernet Employed

The equipment purchases were based on competitive bidding. Accordingly, Ethernet was chosen as the type of network so that the products do not tend to be from one specific manufacturer. Microsoft Windows is the operating system used on the personal computers, and the wireless LAN system uses Motorola's Altea.

"We did not go with wireless LAN just because that was the plan from the outset, but rather it became a necessity," says Katsu Kano, head of the Information and Communications Planning Office of the MPT's General Planning and Policy Division.

If the MPT installed a cable LAN, floors would have to be lifted and the cost would be higher. In addition, the installation would take time and that would delay governmental work.

Nevertheless, because the MPT decided on a wireless LAN the installation took two months. The wireless LAN is the latest system out of necessity.

Expandability Increased

However, the newness of the system is not limited to the wireless LAN. Users can connect to outside databases, such as Nikkei Telecon, and to the Internet, the world's largest personal computer communications network. Being able to get overseas information from the Internet, which covers U.S. news, increases the expandability of the system.

Although Internet will not be used by all MPT employees, the ministry does assign IDs.

"We will demonstrate power in being able to keep in good contact with Diet members," says Kano. Because there are also various types of parliamentary replies, there is the need to convey those all at once in an emergency. At such a time, the MPT's LAN system would demonstrate its greatest power.

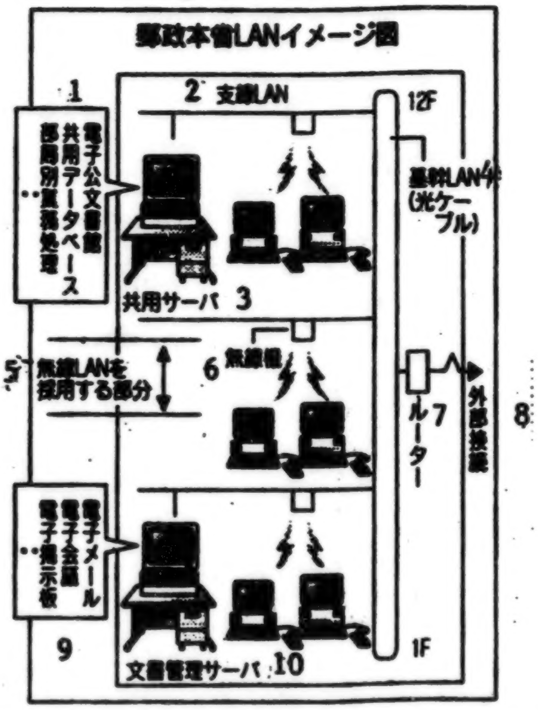
Nevertheless, even with the variety of functions on the system, the users are still in the learning stage. Currently, MPT workers "have not yet reached the stage where they do their work differently." In the MPT there also is the opinion that "the overall results will not be good if the top ranks do not comfortably master the system."

Furthermore, various other barriers lie ahead. For example, in the case of the General Account, because the depreciation period for a personal computer is five years, which is a short time, personal computers are not paid for by government construction bonds. In the General Account, government construction bonds are usually used for roads, bridges, and other structures that last for 60 years. Consequently, except for circuit lines and large-scale servers, budget measures are not used for personal computers, and the situation is such that there still are not enough.

In the U.S., there are noticeable cases of White House bureaucrats who print their electronic mail number on their business cards.

The MPT's LAN is a cutting-edge system, but there is still a long way to go before the Japanese government reaches a level where it utilizes computerized information systems as much as the U.S. government does.

Diagram of MPT's LAN



Key: 1. Processing for individual departments, shared databases, electronic public documents hall 2. Branch line LAN 3. Common server 4. Backbone LAN (optical cable) 5. Where wireless LAN is used 6. Wireless devices 7. Router 8. Outside connections 9. Electronic mail, electronic conferences, electronic bulletin boards 10. Document management server

NEC Develops Prototype Collection/Management System Using Single Optical Fiber

94FE0892E Tokyo NIKKEI SANGYO SHIMBUN in Japanese 5 Aug 94 p 5

[FBIS Translated Text] On 4 August NEC announced that it had trial-produced a system that collects and manages in one location video information from up to 400 video cameras. The system collects video information with a single optical fiber. It is a multimedia system

that handles any kind of information—sound, data, and video. Because the signals within the fiber are analog, the system can be driven by equipment that is simpler than if the signals were digital. NEC aims to make the system practical for use in relaying events and traffic information and for use in monitoring large-scale plants, and hopes to offer it as a product by next spring.

The trial-produced system is made up of an optical fiber that connects directly to an information collection and management center, up to 400 video cameras, and relay devices that convert the camera information into optical signals. A different frequency domain is allotted to each camera so that camera signals do not interfere with each other, and the system is set up so that multiple analog signals can be transmitted simultaneously with one fiber.

In the case where new video data is added to a fiber-optic signal that already carries video data, the optical signals are converted to electrical signals and then added together. Later, the optical signals are retransmitted by lasers in repeaters, so video information can be transmitted clearly to the center from locations as far as 200 km away.

If general-purpose lasers are used in the repeaters, up to 40 cameras can be connected. If lasers suitable for analog signals are used, the system can simultaneously process information from up to 400 cameras. The cameras are set up 10 km apart.

If a similar kind of system used digital signals, an analog-digital converter would be needed for each repeater, and the cost would be more than double that of the analog system.

Up until now, the method used for collecting video and other kinds of information in one place and from many points involved connecting each camera to the center with dedicated coaxial cables and transmitting the information in the form of electrical signals. There were problems with that method in that there is a great deal of signal deterioration, long-distance transmission is difficult, and an immense amount of transmission cable was needed.

If television broadcast cameras are used with the system, NEC sees possibilities for applications in a broad range of areas such as in cable television stations and remote medical treatment.

NTT Develops Database Software "Hypermedia System"

94FE0892F Tokyo NIKKEI SANGYO SHIMBUN in Japanese 5 Aug 94 p 5

[FBIS Translated Text] NTT's Human Interface Laboratory developed database software called the "Hypermedia System" that can collectively manage and search through different kinds of data consisting of animation, still images, text, and sound data. Within a year the Hypermedia System will be used for customer service manuals, and its performance will be evaluated at NTT branch stores throughout Japan. Later NTT plans to add communications functions and to establish the basic technologies for applying the system in a computer "telebook" service that would use telephone lines and radio broadcast waves. Hypermedia, which is the term for databases of multimedia information, is still in the development stage, and now the basic performance of hypermedia software is being evaluated. There are few examples of practical hypermedia software.

Aiming For Applications in Computer Books

What NTT developed is multimedia database software that runs on workstations. A user of the Hypermedia System sees a book displayed on the screen and can use the mouse to turn the book's pages and narrow his or her search down to the information that is needed.

So far NTT has created a 100-page customer service manual for its branch stores, and a 700-page book of software design guidelines. When the user opens the cover of a book on the computer screen by means of a mouse click, the table of contents is displayed; the user can then click on the item he needs to open that page of the book. Each page is displayed with a combination of text and still images. If the user clicks on a special term in the document, an explanation of the term will be shown in a portion of the screen.

In addition, when the user clicks on a still image, video data corresponding to the image (e.g., examples of how to respond to a customer's question on the telephone) is displayed with sound and moving images. Also, if the user manipulates the mouse incorrectly and brings back the same item a number of times, a message screen will appear automatically, and the system will assess how to make the appropriate manipulation or how to use the software correctly.

For now, rather than putting the software on a network, NTT is running it on individual workstations to evaluate its performance. NTT distributes the software on disks to each of its branch stores for evaluation.

In the future, NTT plans to establish technology for distributing software by using an integrated digital communications network (ISDN) and communications satellites. In the case of satellite distribution, about 30 books could be transmitted per second. For that reason NTT thinks its system will be effective as a new way to distribute books and will incorporate functions for transmitting data by an encryption method for copyright protection.

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